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SEALING IN OPEN WATERS.

By Prof. JOHN MILNE, F.R.S., *of the Imperial University, Tokio, Japan.*

NEW laws and new mechanical devices have often much in common. Both may appeal to us on account of their apparent adaptability to the purpose for which they were designed, but before any definite conclusion as to their merits can be reached it is necessary to test them by the results of their operation.

During 1893 England took part in a conference, one object of which was to provide protection to the sealing industry in the North Pacific, and, judging from the comments of the press in England and America, the finding of the arbitrators gave general satisfaction. The award on the main point at issue, relating to the opening or closing of the Behring Sea, was sound, and to all fair-minded people the difficulties of previous years seemed at an end.

How far the regulations intended to protect the sealing industry, which were formulated at the conference, have been effective may be judged of by a consideration of what these regulations were, and of what has occurred since their promulgation.

First, we find that sealing is entirely prohibited within a radius of sixty miles of the Pribyloffs; secondly, that nets, fire-arms, or explosives are no longer to be used; and thirdly, that the Behring Sea is closed to hunters from May 1st to the end of July. Inasmuch as seals do not enter the Behring Sea before May, during August and September there are but few seals which venture far from the rookeries, and even of those that do so, in consequence of the fur being "stagey," from fighting and clambering over the rocks, the skins are no longer in good condition, and finally, as the only weapon left to the hunter appears to be a spear, we may conclude that the regulations have indirectly but practically closed one portion of the Behring Sea to a large fleet of English and American pelagic sealers. The protection of seals, therefore, rests with those who take them on the islands.

Further than this, the regulations state that the close season is to extend over an area north of 35° north latitude, and eastward of 180° meridian of longitude, or generally over the north-east portion of the Pacific Ocean. As to how these regulations will be regarded by nationalities other than those represented by the contracting parties we do not know, but the effect they have had upon those directly concerned has been to send to the Western Pacific a fleet of between sixty and seventy vessels, manned by at least fifteen hundred men.

Should the prohibited area be increased and the regulations become law, it does not seem unlikely that vessels may sail under flags other than those of America and England, while the difficulty of enforcing the new laws over an extensive area like the North Pacific will entail a considerable outlay. Already there are sealers flying German, Japanese and Hawaiian flags, an example of the latter being the steam barque "Alexander," which, with some six or eight other boats, is owned by a syndicate largely, if not wholly, composed of persons interested in the North American Commercial Company, to protect whose rights in the Pribyloffs the existing regulations have been so effective.

If the object of the regulations is to prevent the extermination of the fur seal the rules ought surely to be extended over the whole of the North Pacific, the Okotsk and Japan Seas, and a definite understanding should be arrived at as to the number which may be annually killed on the known breeding grounds. Such regulations would affect Americans, Russians, Japanese, pelagic hunters and all who feel that they have a right to capture whatever they find on open oceans and seas.

The American rookeries, as we have already shown, are now well protected, and all that is required is to definitely fix a limit to the number that may be slaughtered on shore. During the last three years it has been seven thousand, but in previous years it was one hundred thousand.

The Russian rookeries are guarded by an understanding that hunting shall not take place within thirty miles of any place where seals haul up, or within ten miles of any shore. How well this has been enforced may be judged of from the fact that during 1893 no less than five British vessels fell into Russian hands. The steam schooner "Warlock" had her papers, guns and ammunition seized in the port of Petropaulovsky, whither she had gone presumably for some legitimate purpose. The "Maud S.," the "Ainoko," the "Minnie," and the "Arctic" were arrested off the Commander Islands, according to their captors all within thirty miles of land. They were not found hunting, nor does there appear to have been any attempt at escape, believing themselves to be well outside the prescribed limits. Inasmuch as these islands and the neighbouring mainland—like very many other islands in the North Pacific—are represented on charts as being ten to fifteen miles out of their true position, and as foggy weather often makes it impossible to obtain the necessary observations for a true position, the investigation of questions of this description is surrounded with con-

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siderable difficulty. The cases in point, which are but repetitions of old events, however, suggest the necessity of providing against penalties for unintentional infringement, and the desirability of having more accurate surveys.

A circumstance deserving of note in connection with these islands is that the pelagic hunters, not finding enough to pay expenses, quickly deserted them, from which, however, it must not be inferred that there was any diminution in the number of seals hauled up upon the rookeries. One visitor to the islands stated that he had seen more seals in 1893 than he had ever seen previously, and, but for the arrangement with the English not to take more than thirty thousand, double that number might have been secured. It was, however, added that, in addition to the thirty thousand, there were thirty-two thousand more pelts of seals which had been killed the previous autumn.

Assuming the statement to be correct, this autumn killing is apparently a new departure sufficing to confirm the necessity of strictly limiting the number of animals that may be taken on the land.

The attitude of Japan towards pelagic hunting is difficult to understand. Europeans who left Japanese ports for the purpose of hunting sea otters, in 1881, discovered small rookeries of seals upon the Kurils. As these were left unguarded, they were regularly visited until the seals were exhausted. During this period the authorities in Japan not only prevented their own people from engaging in the newly-discovered industry, but so many obstacles were thrown in the way of Europeans that a fleet of about seventeen vessels, in 1893, had dwindled down to two or three. At this juncture the effects of the Behring Sea regulations drove the sixty or seventy vessels to which we have referred to the Western Pacific. Had their number been smaller, judging from the reception they received, they might have shared the fate of the pioneer fleet which had its birth in Yokohama.

Attempts were made to remove the Japanese who had shipped on board these vessels in America. A man-of-war was despatched to watch their movements, and newspapers had references to pirates and poachers who ought to be sunk or driven off the coast. Although a certain section of the Japanese showed displeasure at the advent of a foreign fleet, it may be inferred that when later in the season some forty vessels put into the harbour of Hakodate to ship their catches, to obtain provisions, and to spend their money, the storekeepers felt satisfied.

Up till recently the policy of Japan in these matters seems to have been detrimental to itself. By not having taken efficient means to protect its own rookeries, these have disappeared. The Japanese, either on their own account or in conjunction with Europeans, have been debarred from exploiting wealth near their own coasts, while sealers from other coasts have not been encouraged to winter and refit in Japanese waters, which, with sixty ships, means an expenditure of at least half a million dollars. So far as is publicly known, the only persons who can have benefited are the owners of the northern rookeries, the seals from which at the smallest computation annually consume six million tons of fish in the waters near Japan.

Although the pelagic sealer may feel that in waters where regulations have been applied his career is now ended, the fleet seems likely to be increased to one hundred or one hundred and fifty sail, and we may conclude that the result of the venture in 1893 off the coast of Japan proved satisfactory. The best catches were made in April and May, when one vessel, hunting with seven boats, on one day secured two hundred and sixty-eight seals. In June, although the seals (which are then moving northwards) are plentiful, foggy weather reduces the number of days when boats can venture far from the vessels. In July, excepting for those that choose to linger outside the thirty mile limit of the northern islands, hunting is over.

The total catch for 1893 was from sixty to seventy thousand. Forty thousand of these were shipped from Japan; the remainder were taken to the American coast.

The casualties have been numerous, arising from boats getting lost in the fogs, an unexpected breeze preventing them from regaining their ship, from which they may have ventured ten or fifteen miles, and from other causes. Some crews left their ships and have not since been seen; others, after a pull of one hundred or one hundred and fifty miles, have reached Japan; others have been found in an exhausted condition on the northern islands.

The pelagic hunter, who risks both life and capital, cannot be said to make his money without enduring great hardships and facing many dangers. Whether he should be allowed to exist is a matter for discussion, but if the decision is in his favour—and he represents a large capital, a large force of men, and a considerable revenue—it is clear that regulations to guide his movements should be somewhat more lenient than those already promulgated in connection with the Behring Sea.

SOME EXTINCT ARGENTINE MAMMALS.

By R. LYDEKKER, B.A.Cantab.

IN the article published in the last issue of KNOWLEDGE, under the title of "A Land of Skeletons," we brought under the notice of our readers some of the leading peculiarities of the living and extinct faunas of South America in general and of Argentina in particular, while something was said as to the geological features of the latter country. From the limits of our space we were, however, unable to make any mention of the structural peculiarities of the fossil mammals which are found so abundantly in the superficial formations of the Argentine, and since it is impossible to have an adequate idea of the interest attaching to this fauna without some acquaintance with the anatomy of a certain number of its representatives, we propose in the present communication to take into consideration the leading features of a few of the most remarkable types of one great group. As these animals are known solely by their bones, it is, of course, impossible to avoid the introduction of a certain amount of anatomical details, although we shall endeavour to put these in as popular and least repellant manner as possible.

As mentioned in the article referred to, among all the fossil mammals of Argentina some of the most remarkable are the extinct ungulates, or hoofed mammals, which, exclusive of the horses, deer, guanacos, and elephants, belong to groups almost unknown in any other part of the world.* Before going further we must, however, remind our readers that the existing ungulates are divided into four groups or sub-orders, distinguished from one another by the structure of their feet. Of these the elephants, or proboscideans, as we have had occasion to mention in an article on that group, are specially characterized by having five toes to each foot, and by the two rows of bones in the wrist and ankle being arranged one above another in a linear manner; while the huckle-bone, or astragalus, of the ankle articulates with the leg-bone by a flat surface. On the other hand, in both the odd-toed or

* During the Pleistocene a few ground-sloths and glyptodonts entered North America.

perissodactyle ungulates, as represented by the rhinoceros and horse, and the even-toed or artiodactyle group of the order, of which we have familiar examples in the pig and the deer, the toes are never more than four in number, the bones of the wrist and ankle interlock or alternate, and the huckle-bone has a pulley-like surface for articulation with the large bone of the leg. Whereas, however, in the former of these two groups the middle toe is larger than either of the others and symmetrical in itself, in the second group it is the two toes corresponding to the second and third of the human limb which are larger than the others, while they are also symmetrical to a line drawn between them. There is likewise a well-marked difference between the huckle-bones of the two groups. The fourth group, represented only by the various species of hyrax—the coney of Scripture—need not detain us here.

Turning to the proper subject of our article, we commence our notice with one of the largest of the Argentine mammals, which derives its name of *Toxodon* from the peculiarly curved or bow-like form of its long molar teeth. As shown by the accompanying figure of a skeleton preserved in the La Plata Museum, this gigantic animal, which rivalled the large Indian rhinoceros in size, is remarkable for the peculiar lowness of the fore-quarters, in consequence of which the enormous head is carried much below the line of the back.* Since the creature has much the general appearance of a rhinoceros, as shown by its relatively short and stout neck and limbs, while the number of toes to each limb is three, of which the middle one is symmetrical in itself, an observer might, at first sight, be disposed to place the toxodon among the odd-toed ungulates. A closer examination would, however, show that while the middle toe is not markedly larger than either of the others, the bones of the wrist are arranged on the linear plan, while in the ankle the upper surface of the huckle-bone is nearly flat, or intermediate between that of the elephants and the odd-toed ungulates. Omitting mention of certain other minor peculiarities in the structure of the limbs, if we now turn our attention to the teeth, we shall find that these also present features unknown in any living ungulates. We find, for instance, in the first place, that the upper jaw is furnished with two pairs of permanently-growing chisel-like teeth, comparable to the single pair of incisors in the rodents or gnawing mammals; these being opposed by three pairs of nearly similar, although horizontally placed, lower teeth. Such permanently growing incisor teeth are, however, paralleled among existing ungulates in the hyrax; but the toxodon stands alone in the order from the circumstance that the molar teeth likewise grow throughout life, instead of forming roots. Here, then, we have another point of resemblance in the toxodon to the rodent order. When we examine the form of the grinding surface of these molar teeth, there does not appear any marked resemblance to those of any existing ungulates. The link is, however, furnished by certain allied forms from the older Tertiary beds of Patagonia, known by the name of *Nesodon*, of which the first fragmentary remains were brought to Europe by Darwin, in the "Beagle"; the toxodon being confined to the Pampean deposits and the underlying beds

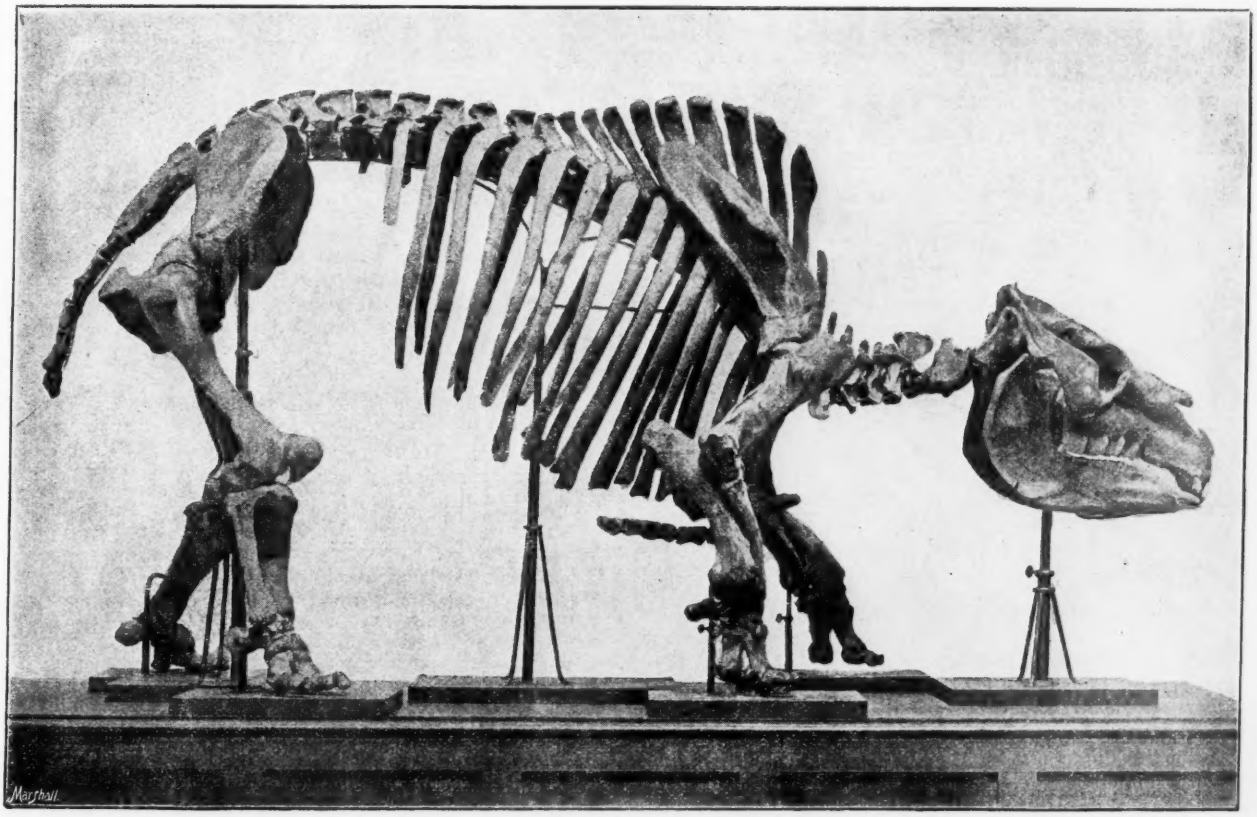

FIG. 1.—Skeleton of the Toxodon. About one-twelfth natural size.

* This feature is, perhaps, somewhat exaggerated in the restoration.

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of Monte Hermoso. Now, in the nesodons, the structure of the molar teeth clearly approximates to that characterizing the odd-toed ungulates, although belonging to what naturalists term a more specialized type. It is further noteworthy that in these nesodons, although the molar teeth grow for a considerable portion of life, yet they eventually form roots in the ordinary manner; the same being true of the incisors, with the exception of a single pair, which grow permanently. We see, therefore, that the permanently growing teeth of the toxodon are a specialized feature, which do not justify the reference of the creature to a separate subordinal group, while the older genus shows that these animals are clearly allied to the odd-toed ungulates, although sharply distinguished by the structure of their feet. Their feet being of a less specialized type than those of the latter (as is especially shown by the almost flat huckle-bone), while their teeth are more specialized, it is further evident that neither group can be ancestral to the other. Hence, the toxodon and its allies must be regarded as forming a separate subordinal group of equal value with the other sub-divisions of the great ungulate order. Where these remarkable creatures branched off from the primitive ancestral types of the latter, and how they first obtained an entrance into South America, where they gradually increased in size and specialization till the period of the Pampean, when they finally disappeared, is still an unsolved problem.

The interest of the toxodons does not, however, by any means end here. We have seen that the toxodon itself shows certain resemblances to rodents in the structure of its teeth; while it will be perfectly evident that such resemblances indicate no genetic affinity between the two groups, seeing it is certain that rodents are neither the ancestors nor the descendants of the toxodons. In a much smaller animal known as the typotherium, of which the skull is shown in the accompanying figure (2), these

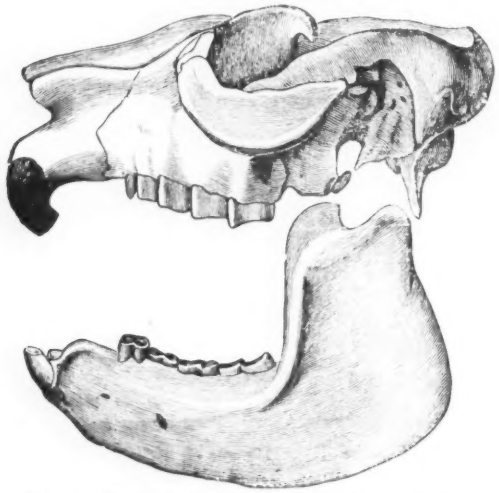

Fig. 2.—Skull of the Typothere. Half natural size.

rodent resemblances are, however, still more pronounced, as is especially shown by the incisor teeth, which are essentially those of a rodent. Moreover, in the hind feet the toes had lost the hoofs characterizing the more typical ungulates, and were probably protected by small nails. A still further step is exhibited by a much smaller Argentine mammal, of the approximate size of a hare, and rejoicing in the euphonious name of *Pachyrucus*. If it were not for the intermediate links, this creature would almost certainly be put down as a rodent, with which group it agrees in the structure of its teeth and toes, as well as in many other parts of the skeleton. Nevertheless, it is clearly a near ally of the typotherium, and therefore a member of the toxodon group. Here, then, we have one of the most remarkable known instances of the phenomenon of parallelism—a feature to which especial attention has been directed in previous articles. We have, in fact, displayed before us the origin of what we may call a rodent-ungulate; that is to say, an animal which, while certainly an ungulate by descent, has acquired such a marked resemblance to a rodent that, if we had not the intermediate links, it would certainly be regarded as a member of the same order. This wonderful instance gives us some insight into the intricacies of evolution, and serves to show the amount of value to be attached to the majority of phylogenies of the animal kingdom.

In addition to the slightly grooved huckle-bone, the toxodon group is characterized by at least one of the upper incisor teeth growing throughout life, and by the molar teeth being either rootless or not forming roots till a very late period. There is, however, a second group of allied extinct ungulates peculiar to the Argentine, in which all the molars are rooted at the usual period, while the huckle-bone is as flat as in the elephants, although of somewhat different form. This group is represented solely by two genera, both of which are confined to the Patagonian deposits, where they are represented by animals rivalling rhinoceroses in size, and furnished with molar teeth somewhat resembling those of the latter. One of these creatures, on which the somewhat cumbersome name of *Homalodontotherium* has been conferred, presents the rare peculiarity of having the teeth arranged in a regular even series without gap or interval, and with their crowns of equal height. Very different in dental characters were the members of the allied genus, *Astrapotherium*, in which each jaw was furnished with a huge pair of tusks, those of the lower jaw curving outwards and upwards after the manner of those of a wild boar, while both were kept sharp and keen by their points wearing against one another. In the presence of these enormous upper tusks, the astrapotheres resembled the extinct uintatheres of North America, alluded to in our article on "Tusks"; but they differed in the possession of tusks in the lower jaw, while it is probable that those of the upper jaw were incisors instead of canines. The most curious feature connected with these animals is, however, the close resemblance of their upper molar teeth to those of rhinoceroses; the similarity being so marked that if we were acquainted with the South American animal only by these teeth, it would probably be classed with the rhinoceroses. From the structure of the bones of the ankle it is, however, quite certain that these two groups of ungulates have no direct connection with one another, and that their common ancestor must have had molars of a much simpler type of structure. It follows, therefore, that the form of molar teeth characterizing both the astrapotheres and the rhinoceroses must have been evolved independently in the two groups; and that we have consequently here another very interesting case of parallelism. Although this type of tooth (which it must be remembered is one of considerable complexity) is admirably adapted for crushing vegetable substances, it is by no means the only one which could have been evolved from what we may probably regard as the primitive type; and it is, therefore, hard indeed to see how it can have been produced by evolution unaccompanied by design.

Strange and unique as are the foregoing creatures, they are exceeded in the former respect by the long-necked and long-limbed animal rejoicing in the name of *Macrauchenia*,

so termed on account of the elongation of the vertebræ of the neck, which were first brought back by Darwin from the superficial deposits of Patagonia. In its general form the macrauchenia, of which a complete skeleton from the Pampean formation preserved in the museum at Buenos Ayres is represented in the accompanying figure (3), the nostrils is carried to a still greater degree. That a land mammal with its nostrils situated in this unusual position could not have managed to exist without a trunk is pretty evident, and we may therefore conclude that the macrauchenia was so furnished; while from its long slender neck and limbs we may further infer that it was

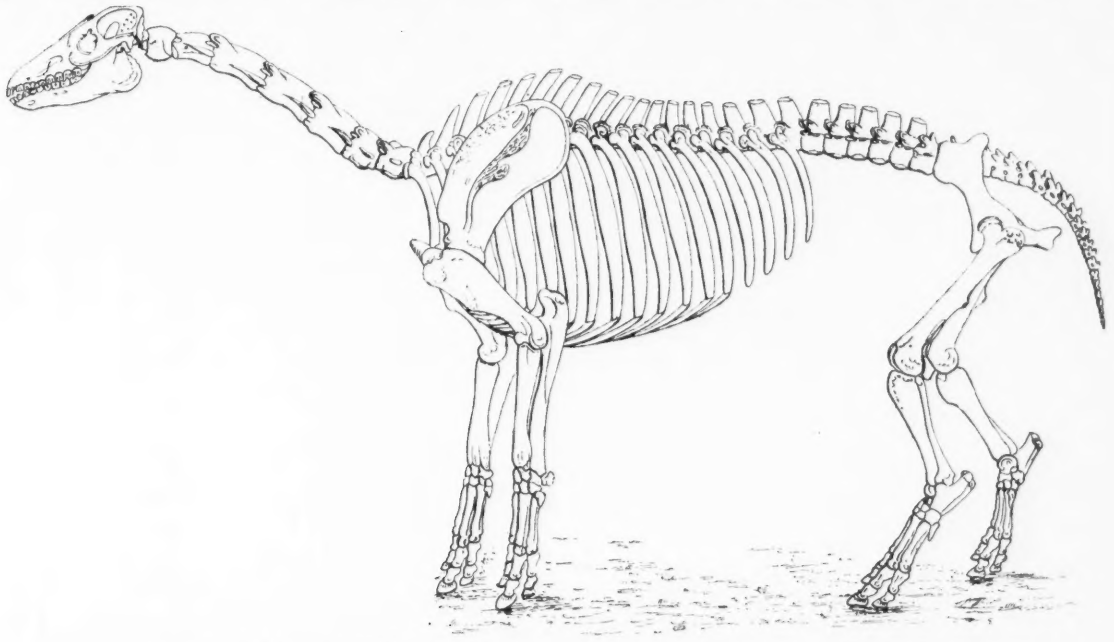

FIG. 3.—Skeleton of the Macrauchenia. About one-fifteenth natural size. (After Bravard.)

somewhat recalls a camel; and it is a curious circumstance that in common with that animal and its allies it differs from all other ungulates, with the exception of certain kindred Argentine forms, in that the vertebral artery of the neck pierces the sides of the vertebræ to take a course within the spinal canal, instead of passing merely through a loop of bone on the exterior. This remarkable resemblance is not, however, indicative of any affinity between the two animals, since if we look at the feet of the macrauchenia we shall find that they are of the odd-toed type, and are each furnished with three digits. Moreover, the huckle-bone has the pulley-like upper surface characterizing the odd-toed ungulates; while as the teeth approximate to those of the latter, we might be inclined to place the creature in that group. The wrist and ankle joints are, however, formed on the linear plan, and exhibit certain other departures from the odd-toed type, and it is therefore evident that the macrauchenia and its allies constitute a third subordinal group of extinct ungulates peculiar to South America. Although it is by its foot-structure that the macrauchenia is thus separated from all other members of the order, its most remarkable peculiarity is to be found in the structure of its skull. In an ordinary well-regulated mammal the aperture of the nose is situated quite at the anterior extremity of the skull. In the macrauchenia, however, the said aperture is an egg-shaped vacuity in the forehead, placed almost between the eyes. Some approximation to this remarkable arrangement is presented by the living tapirs, but it is more nearly paralleled by the elephants, and still more closely by the aquatic dugong, while among whales the backwardation (if we may coin a word) of

an inhabitant of open plains or thin forest, and was not a frequenter of marshes and swamps. It may be added that in its uninterrupted and even series of teeth the macrauchenia differs from all existing mammals save man, and agrees with its distant cousin the homalodontothere.

From its large size, the peculiar position of its nostrils, and the characters of its molar teeth, the zoologist is at once led to infer that the macrauchenia is a highly specialized creature; and it is of the greatest interest to find that this inference is converted into a certainty by the discovery of certain kindred forms in the older formations of the Parana and Patagonia, which are evidently the ancestral types from which the Pampean genus has originated. All these creatures were of relatively small size, with their molar teeth more closely resembling those of the odd-toed ungulates, and they show a gradual transition in regard to the position of the nostrils from the type of the macrauchenia to the ordinary form. The evolution of such an extraordinary creature as the one under consideration is, therefore, fully explained, although we have yet to learn the special reason for the peculiar position of its nostrils and the development of a trunk.

More or less intimately allied to the ancestors of the macrauchenia were certain contemporaneous ungulates from Patagonia, of which the largest did not exceed a tapir in size. With molar teeth so like those of the odd-toed ungulates from the Paris basin, described by Cuvier as *Palæotherium*, these Patagonian ungulates differed from the macrauchenia in having the dental series reduced in number and interrupted by gaps. Their most remarkable peculiarity is, however, to be found in the structure of their feet, which, in some forms at least, resembled those

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of the extinct three-toed horses known as the hipparions; the middle toe being very large, while the two lateral ones were small and functionless. There is, moreover, some reason to believe that in one genus the toes were reduced to a single large one on each foot, as in the modern horse. Be this as it may, the fact that there existed in South America a group of ungulates which exactly paralleled the horses in the evolution and structure of their feet is one of the most wonderful features in mammalian development that has ever come under our notice, and serves to render these prototheres (as the group is called) worthy of the best attention of the student of parallelism. It may be added that the high specialization of these animals is of itself sufficient to dispose of the idea that the strata in which their remains are entombed are equivalent in age to the lower Eocene of Europe.

This completes our survey of the groups of extinct ungulates peculiar to South America, which, brief as it is, serves to show how interesting they are alike to the pure anatomist and to the evolutionist, and also indicates their importance from a distributional point of view. With regard to the latter, it may be observed that since all these animals are clearly more or less intimately related to the ancestors of the odd-toed ungulates of the Old World and North America, while the edentates of South America have no near relatives elsewhere, and the extinct marsupials of the same area appear akin to those now living in Australia, it would seem that at some remote epoch there must have been a brief connection between North and South America, during which one or more primitive ungulates obtained entrance into the latter area, where they subsequently multiplied and developed into the numerous forms above noticed. If this be true, it will be evident that South American ungulates were originally immigrants from the north; those which are absolutely peculiar to the country having originated from an incursion which took place early in the Tertiary period, while the later types nearly akin to those of North America and the Old World did not arrive till the late Pliocene epoch, when a second connection must have been established between the two continents.

WEIGHING THE EARTH.

By J. J. Stewart, B.A., B.Sc.

SINCE Newton's splendid verification of the theory of universal gravitation, several attempts have been made to determine the mass of our planet, and hence the mean density of the materials composing it. Amongst the earliest of these which approached accuracy was the experiment by Henry Cavendish, the eminent philosopher, who anticipated last century some of Faraday's remarkable electrical discoveries. The method he employed was suggested by the Rev. John Michell, and is generally known as the Cavendish experiment. Michell constructed an apparatus suitable for the operation, but does not seem himself to have made any experiments; and alterations and improvements were made in the apparatus by Cavendish. The main principle of the method is that of comparing the attraction exerted by a leaden sphere on a small ball with the attraction exerted by the earth on the same ball—that is, with the weight of the earth. In the apparatus of Michell and Cavendish the attraction between two spheres of moderate size is balanced by the elasticity of a wire; the amount of torsion in the wire required to resist the attraction of the spheres being found, this gives the force of attraction which is equal to it. This force is then compared with the attraction of the earth on one of the spheres—that is, with the weight of the sphere; and hence, as the diameter and therefore the volume of the earth is known, its mass is deduced.

Michell's original apparatus consisted of a wooden arm six feet long, made so as to unite great strength with little weight. This arm being suspended in a horizontal position by a fine wire, from each end of it was hung a leaden ball about two inches in diameter, and the whole was enclosed in a wooden case to protect it from draughts of air. The force required to turn the arm is no more than that necessary to twist the suspending fibre, and as this was very slender, even a very small force, such as that produced by the attraction of a leaden weight a few inches in diameter, is sufficient to produce a sensible displacement of the arm. As the force with which the balls are attracted is excessively minute, not more than one fifty-millionth of their weight, a very small disturbing force is sufficient to destroy the success of the experiment. Cavendish found that the disturbing force most difficult to guard against was that arising from variations of temperature. Suppose that one side of the containing case is warmer than the other, this will cause the air next it to be rarefied, and it will consequently rise, while the air on the cooler side will descend, and thus currents will be produced which interfere with the deflections of the instrument to be observed.

In the apparatus as modified by Cavendish the balls were suspended by wires from a light arm made of deal and strengthened by a silver wire, so as to have the form of an open girder; thus lightness and strength were combined. The apparatus was placed in a room kept constantly closed, and the motion of the arm was observed from the outside by means of a telescope; thus errors, which might arise from the approach of the observer causing changes in the temperature, were avoided. The leaden weights, which were spheres a few inches in diameter, could be moved from the outside by means of a cord passing over a pulley. The weights were placed close to the balls, so that they tended to twist the suspending fibre round in the same direction and cause a movement of the arm. They were then turned round and placed on the opposite sides of the respective balls, so that they tended to move the arm round in the opposite direction. Between these observations of the deflections produced, the line joining the weights was set at right angles to the arm, so that they exerted no attraction on the balls, or rather, equal and opposite attractions which neutralized each other. The position of the arm could be read off on ivory scales graduated to one-twentieth of an inch, and read by a vernier to one-hundredth of an inch, and estimated to less. The scales were lit up by lamps placed outside the chamber, and their light was thrown by a lens on to the scales, the chamber being otherwise dark.

When the arm was drawn aside it vibrated backwards and forwards, the vibrations lasting a long time; thus the position that would be occupied by the arm if it were at rest had to be calculated. This was done by observing three consecutive extreme positions of the arm, the first and third being towards the same side and the second one in the opposite direction. The intermediate observation was compared with the mean of the first and third; this gave the position the deflected arm would have occupied if it had come to rest, damping of the vibrations being allowed for.

Next, the time of vibration was measured; from this could be deduced the force acting on the suspended balls. Possible error due to magnetic effects was looked for, but

the observations were free from this. The effect of the leaden spheres on the arm was found to increase or diminish with standing, and this was found to be due to a difference of temperature between the weights and the case. In the first experiments made, the wire by which the arm was suspended was thirty-nine and a quarter inches long; its material was copper coated with silver. Its stiffness was such as to make the arm perform a vibration in about fifteen minutes. In the first observations the rods by which the leaden weights were suspended were of iron, but care was taken that there was nothing possessing magnetic properties in the arm. In later experiments the iron rods were replaced by copper, but no change in the observations was caused. Another series of observations was also made, using a stiffer wire. The force required to draw the arm aside, in opposition to the force of restitution in the twisted fibre, was found by observing the time of a vibration and calculating from this.

The following may serve as an example of the observations made :—

Motion of the arm on moving weights from positive position to middle position ... ... = 15·22
Motion of the arm on moving weights from middle position to positive position ... ... = 14·5
Time of one vibration when in middle position ... = 14m. 39s.
" " " " positive position ... = 14m. 54s.

The positive and negative positions were those in which the leaden sphere tended to cause a twist in one direction and in the other respectively. The middle position was that in which the spheres were on the line bisecting the middle of the arm.

The density of the earth was deduced from the observations by comparing the force of attraction of the leaden weights on the balls suspended from the arm with the force of attraction of the earth on the same balls—that is, with their weight. The question is: What must the mass of the earth be when it attracts a ball on its surface—that is, four thousand miles from its centre—with a force greater in a known ratio than that with which the same ball is attracted by a sphere of lead of known mass, placed at a measured distance? Knowing the law of gravitation, that masses attract each other with a force varying as the product of their masses, and inversely as the square of the distance apart of their centres of gravity, we at once find what the mass of the earth must be, and this divided by the volume of the earth gives its mean density.

The corrections which Cavendish had to apply to his observations were :—

1. For the effect which the resistance of the arm to motion had on the time of vibration.
2. For attraction of the weights on the arm itself.
3. For their attraction on the farther ball.
4. For the attraction of the copper rods on the balls and arm.
5. For the attraction of the case on the balls and arm.
6. For the alteration of the attraction of the weights on the balls according to the position of the arm, and the effect which this had on the time of vibration.

The last correction was of the most importance; the others did not affect the result much.

Cavendish says :—" By a mean of the experiments made with the wire first used, the density of the earth comes out 5·48 times greater than that of water; by a mean of those made with the latter wire it comes out the same. The extreme results did not differ from the mean by more than one-fourteenth of the whole, and therefore the density should seem to be determined hereby to great exactness."

The value thus found differs but little from the latest determinations made by similar methods. Prof. Poynting's result (which I will refer to later) obtained quite recently, after great precautions were taken to secure accuracy, is 5·493. It is noteworthy that the guess made by Newton in the century preceding Cavendish's experiment, for the density of the earth, namely, five to six times the density of water, is remarkably near that which seems to be the value as determined by the best method.

The operation of weighing is so familiar to all that many are apt to forget what is actually done when anything is weighed. The method of weighing is adopted as a ready and easy means of finding the mass of a body—that is, the quantity of matter in it. This is done by comparing the attraction of the earth on the body in question with its attraction on another piece of matter whose mass is known. When the masses in the two scale pans of a balance are equal the mass of the earth attracts them equally, and the beam of the balance stands horizontally; the balance is in equilibrium, and the substances in the two pans are said to be of equal weight. But the attraction of the earth on a mass near its surface depends on the distance of that mass from the centre of the earth, so that a pound has less weight at the top of a mountain than in the valley below. The weights of bodies vary according to their position on the earth's surface, and the same mass has a greater weight at the poles than at the equator, because in the former place it is nearer to the centre of the earth, and the earth's attraction for bodies outside it is the same as if the whole mass of the earth were concentrated at its centre.

Again, at the equator the motion of the earth about its axis tends to cause a body to fly away from the axis and to decrease the weight of the body. Thus the weight of a body, far from being a constant quantity, varies as the body is moved from place to place. Nevertheless, the method of weighing is an accurate way of determining the amount of matter in a given body, because by this operation we simply compare two attractions, and the forces of attraction on the body and on the standard weights with which it is compared vary equally as the balance is moved from one position to another; thus, although a body is lighter at the equator, so also is the standard pound against which we compare it.

The comparison of weights is simple and familiar enough, but can we weigh the earth itself or find its mass? What can we compare it with? Here, again, what is to be done is to compare two attractions. If we can find the attraction of some mass—a part of the earth—on another mass, and then compare this attraction with that of the earth on the same mass—that is, with its weight—the problem is solved.

Several methods have been suggested for doing this. Perhaps the earliest attempt was that made by some French geographers, who observed by what amount the plumb line was deflected from the vertical owing to the attraction of a neighbouring mountain. This experiment was performed near Quito, in the Andes, but the observations were but rough and inaccurate; the deflection seemed to be quite noticeable, but the observations were taken in a tent, and it would be impossible under such conditions to guard properly against currents of air, which would disturb the instrument.

Later, the suggestion that this method of the plumb line should be used to find the earth's density, by taking observations near some suitably-shaped mountain in the British Isles, was made to the Royal Society by Maskelyne, the Astronomer-Royal of that time. Schehallien, a mountain in the Scottish Highlands, was finally fixed upon, and the operation carried out there, the results

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being published in 1775. By trigonometrical measurements the distance between two points, one north and the other south of the mountain, was found, and from this the difference of their geographical latitudes was got. The true latitude of each point chosen was also determined by astronomical observations. The difference between the true and geographical latitude of the two stations depends on the amount by which the mountain deflects by its attraction the plumb line which was used to determine the vertical. This deflection was in an opposite direction at the two stations, in one case towards the north and in the other towards the south. The point south of the mountain had its latitude made less than the geographical latitude, because it was in the northern hemisphere; the point on the north side had its latitude made greater. Thus, if the mountain had been symmetrical in shape (and it was chosen because it approached to symmetry) the difference of the astronomically found latitudes would have been greater than the difference of their geographical latitudes by double the deviation produced on the plumb line by the mountain's attraction.

By laborious measurements the form of the mountain was next observed. As nearly as possible, its geological composition and the specific gravity of its material were determined, and then the attraction of this quantity of matter of approximately known distribution and density was compared with the attraction of the earth, which exceeds the former in a known ratio. Maskelyne's result for the density of the earth was 4·48—four and a half times denser than water; but it is pretty certain from later and better measurements that this value is considerably too low. The great defect of this method is the uncertainty which must occur as to the internal composition and structure of the mountain itself and the surrounding country. Cavities might be present in the hill, or places where the matter was much lighter or much heavier than the specimens taken from the surface; and all such unknown sources of error militate against an accurate determination. The same method has been employed by James, at the hill called Arthur's Seat, near Edinburgh.

Another and different method of finding the earth's mean density is that used by Airy. This consists in comparing the time of vibration of a pendulum at the top and at the bottom of a deep mine. The time of swing of a pendulum depends on the attraction of the earth upon it. At the bottom of a mine the outside layers of the earth consisting of the mass contained in the outer skin, whose thickness is the depth of the mine, cease to exert an attraction on masses within—the attractions of separate portions of this outer shell at opposite sides of the earth mutually destroy each other. The attraction, then, on a pendulum at a depth within the earth's surface consists of that produced by the inner core, and at the bottom of the mine we have come nearer to the core, but its volume and mass is decreased as the cube of the radius, so that its attraction is less than at the surface. On the other hand, the attraction above ground consists of that due to the core as well as that exerted by the shell. The observed times of vibration of the pendulums give a means of determining the amount of these two attractions—that of the core and shell respectively.

The volume of the outer shell is known, for it follows at once from the known depth of the pit, and it has to be assumed that the mass and density of the shell can be determined from observations on the geological strata passed through during the descent. Here comes in the weak point of this method; the true mass of the outer skin must remain uncertain.

Airy first attempted to apply this method at a mine in Cornwall, but met with various mishaps through accidents to his apparatus, and it was not till after more than twenty years from these first experiments that he, with the help of numerous assistants, carried to a successful conclusion his experiments, at the Harton coal pit, in the north of England. Pendulums were made to vibrate at the upper and lower stations. These were connected and compared electrically, and thus the intensity of gravity at the top and bottom of the mine was determined, and hence the earth's density.

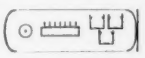
The result of this experiment comes out considerably higher than that by other methods, viz., 6·56 for the density of the globe, and we cannot have the same confidence in this determination as in that of the results of the Cavendish experiment, which do not differ much amongst themselves. All that Airy claimed for his method was that it was worthy of comparison with the previous observations, and deserved to stand on an equal footing with them.

(*To be continued.*)

THE COFFIN OF THE BUILDER OF THE THIRD PYRAMID.

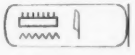
By J. H. Mitchiner, F.R.A.S.

In the December number of Knowledge an interesting article appeared under the above title, in which Mr. Read calls the attention of English readers to an article written by Herr Kurt Sethe, published as far back as 1892 in the *Zeitschrift für Ägyptische Sprache* of Leipzig. Herr Sethe contends, on presumed philological grounds, that the coffin lid of Men-Kau-Rā, of the fourth dynasty, B.C. 3633, is not the original lid, but a later coffin lid substituted for the original, and that it probably dates from about the time of Tirhakah, B.C. 700. No arguments are offered in support of this extraordinary conclusion, beyond a general statement that the writing on the lid is ideographic in character. Moreover, it is asserted that the early texts are very deficient in these ideographic signs, and that the name of Osiris written with the ideographic prefix, as on the lid of this coffin, cannot be found so written till the middle of the fifth dynasty.



Philological study of all ancient languages reveals that among primitive peoples, however much divided by racial or climatic conditions, the representation of ideas invariably follows one common course of development. First, objects are depicted, then sounds are depicted, and ultimately an alphabetical system is evolved. Applying this law to the hieroglyphical writing of the Egyptians, in order to gauge the value of the argument of Herr Sethe, we are met by an initial difficulty. At what date in the distant past are we to ascribe to the Egyptians a system of pure picture-writing? of writing such as the primitive symbols of the Mexicans?

Our knowledge of Egyptian history commences with Mena, B.C. 4400. Only very recently has it been discovered how it is that Egyptian tradition observes a complete silence as to history prior to this date. Mena was the Thinite Pharaoh who succeeded in restoring a native dynasty after the conquest of Egypt by the old Babylonian empire; and, it may be, the infinite pains taken by the Egyptians at a later date to destroy all evidence of the long and hated Hyksos interregnum was but a traditional repetition of similar efforts on the restoration under Mena, after the Babylonian conquest. We have no means of knowing the duration of that conquest, nor the names and number



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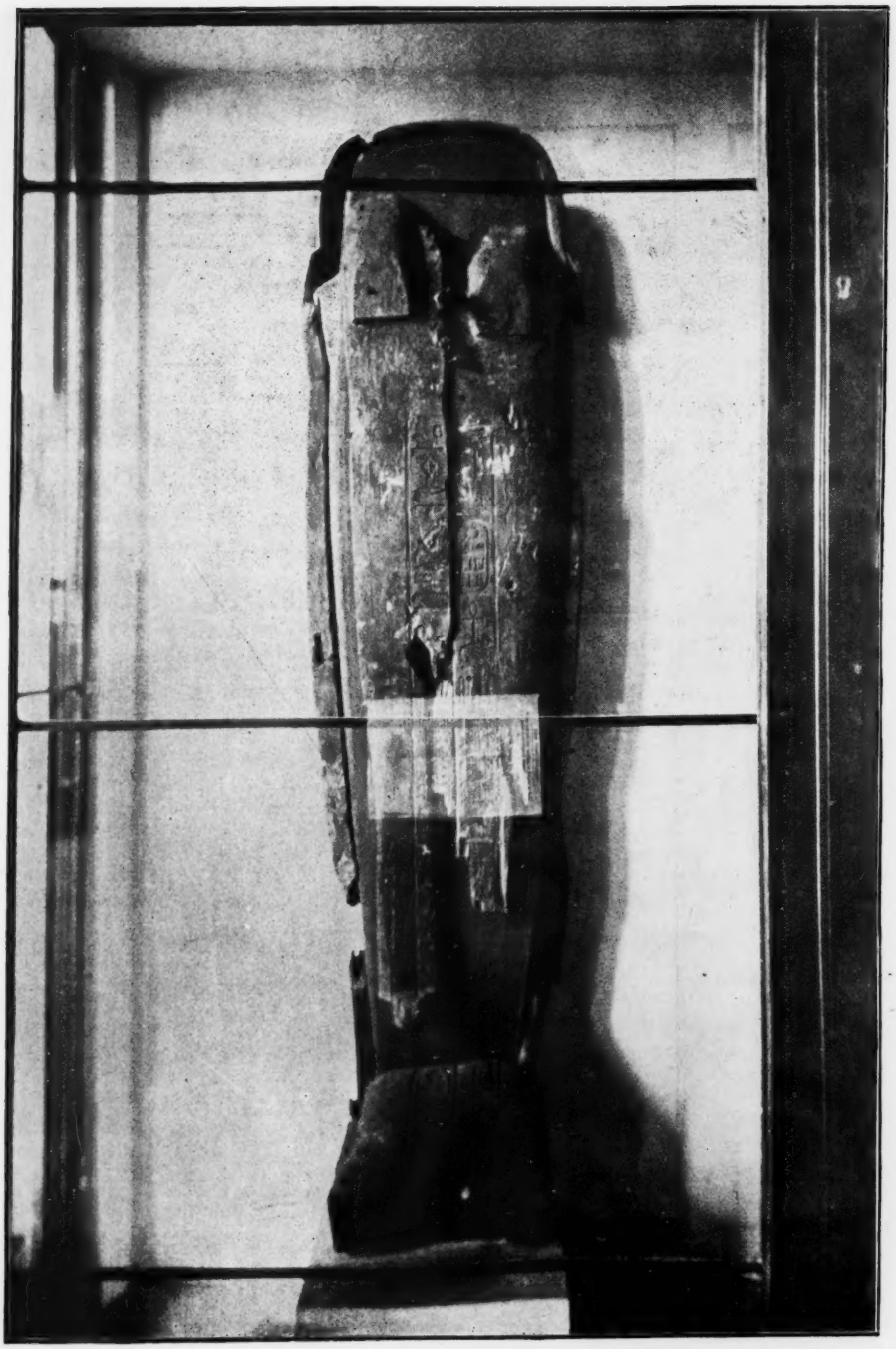

THE COFFIN OF THE BUILDER OF THE THIRD PYRAMID,
now in the British Museum.

From a Photograph by Mr. A. Fisher, of Southsea.

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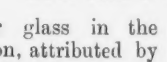
of the native kings who reigned in Egypt anterior to it. We are compelled to commence with Mena. Yet at the period of this monarch, B.C. 4400 years, we find the Egyptians in possession of a perfectly developed system of writing, made up of alphabetical and phonetic characters, with a number of their ancient ideographs retained as determinatives. The Assyrian, Median, and Babylonian cuneiform writings also display slow development from old forms of picture-writing, obtained by very tardy degrees, extending over many centuries, and like the Egyptians, retaining as determinatives many of their ancient ideographs. China, after the lapse of three thousand years, has not yet emerged from its system of ideographs.

In the absence of records of Egyptian civilization pointing to a picture-writing age, we cannot find the base on which Herr Sethe erects his theory. Egyptian history, unlike the history of Greece, furnishes no archaic period of art and literature. Go back as far as we may, we fail to reach the cradle of its civilization. Its art supplies no *Branchidæ* statues, such as Greece furnishes, telling of the rude artistic efforts of the race prior to Myron and Phidias. A retrospect of five thousand years does not help us. The statues of Sepa and Nesa* betray an art with aims and instincts well developed; and they date from B.C. 3900! The close of the third dynasty produced the masterpieces of ancient art. Those two famous statues of Ra-hotep and his wife Nefert (the beauty), exhibited under glass in the museum at Boulak, are, with good reason, attributed by M. Marriette to the reign of  Seneferu, B.C. 3766! The extreme beauty of the sculptures surpasses all subsequent work, and their interest is increased by the certainty of their great age. As in art, so is it in literature.

"We can hardly hesitate to assume," says Bunsen,† "whatever preconceived ideas it may disturb—that this genuine Egyptian writing, combining phonetic with figurative signs, is, in its essential elements, *at least* as old as the time of Menes."

Lid of Coffin of Menkaura, B.C. 3633.

Translation of the left hand column.	*Translation of the right hand column.*
Nut	Osiris,
She grants	King of the North and South,
that thou	Menkaura,
shalt be	living for ever;
a god;	born of Heaven,
never more	conceived by
shalt	Nut;
thou have	thou comest
enemies,	of the race
King of the	of the
North and South,	god
O Menkaura,	Seb.
living for ever.	Thy mother

We cannot reach, therefore, by history, tradition, or monumental remains, to the distant archaic age of Egyptian pure picture-writing. Of the four thousand years during which we are able to study the Egyptian records, we find that literature, like art, was constantly fluctuating; its eras of decadence being followed by intervals of revival. At some periods the scribes attempted to discard the use of ideographs, yet there appears to have been a constant, almost persistent, tendency to revert to the principles of the old system. We must remember, also, the latitude allowed the scribes, who followed no normal rule in writing, but often substituted one phonetic hieroglyph for another in cases where they had the same sound. Moreover, they omitted or inserted ideographs at times, in an apparently arbitrary manner, and for the sake of harmony of appearance substituted vertical for horizontal forms, as s ñ "they," or , as it suited the stone to be inscribed.‡

Having regard to these facts, the attempt to erect an important hypothesis on the bare retention or omission of ideographs in a solitary inscription, or even from a host of inscriptions of any particular period of Egyptian history, seems to be rash to the last degree. There is abundant evidence to show that in the retention or omission of ideographs, throughout an extensive country and during a number of centuries, the writing constantly underwent changes and modifications. Whenever the object itself was the ideograph, they almost invariably at one period omitted the ideograph altogether, as in *kaf*, over an ape, and in *au*, over a cow. Moreover, hieroglyphical writing, especially in the case of temple inscriptions, unquestionably contained an *esoteric* as well as an exoteric meaning. By the use of ideographs the meaning packed as closely as the Latin. Hence it was retained for those inscriptions to a very late date. Plutarch mentions the inscription over the temple of Sais, comprising an old man, a youth, a hawk, a fish, and a hippopotamus, — , meaning "O all, whether

* "History of Art in Ancient Egypt."—Perrot and Chipiez.

† "Egypt's Place in Universal History," vol. I., page 8.

‡ Wilkinson's "Egypt."

old or young, know that the gods hate impudence." This inscription is ideographic throughout.*

That the ideographic picture-writing method preceded the phonetic and alphabetical is abundantly clear, and, in the absence of all knowledge of the archaic period of Egyptian writing, any hypothesis built simply upon the presence or absence of an ideograph in a well-developed system of writing, and made the basis for fixing a definite date, and this without a shadow of other supporting evidence, is scarcely adapted to receive serious notice at the hands of our best Egyptologists.

It is doubtful if the entire number of inscriptions existing in the museums of the world, of periods anterior to the fourth dynasty, are sufficient to supply a satisfactory conclusion on the use or omission of determinatives in early writing. Bunsen writes†—"We may confidently state that the principle of determinatives was in full activity at the *commencement* of the chronological epoch." According to Herr Sethe, they do not occur in general use until the twenty-sixth dynasty, and, because the word "Osiris" on the coffin-lid of Menkaura is written with the determinative, he, on this ground, assumes the manufacture of another coffin two thousand years afterwards.

The hieroglyphic writing subsequent to the fourth dynasty, and dating from that period to the twenty-sixth dynasty, when submitted to a perfunctory examination, might lend an appearance of force to the contention. But the conclusion vanishes on attentive comparison. In the majority of pyramid texts, published by M. Maspero,‡ the peccant determinative in the name of Osiris is more frequently absent than otherwise, but closer study of other monumental inscriptions forbids any inference to be drawn, such as enunciated by Herr Sethe. In the long era extending from the fourth to the twenty-sixth dynasties, the word "Osiris" is found written both with and without the determinative. Appended are a few examples :—

Twelfth dynasty.—Liverpool Museum. Inscription on sepulchral monument. Osiris written *without* determinative.

Twelfth dynasty.—Inscription on tomb of the reign of Amenhat III. Osiris written *with* the determinative.

Thirteenth dynasty.—Inscription on leaf-shaped dish of green basalt. Osiris written *without* the determinative.

Thirteenth dynasty.—Fragment of dark wood, carved with the inscription "Royal oblation to Osiris, dwelling in Amenti." Osiris written *with* determinative.

Eighteenth dynasty.—Inscription on stela in museum of Marseilles. Osiris written *with* determinative.

Nineteenth dynasty.—Monumental inscription to Piaai. Osiris written *without* determinative.

Nineteenth dynasty. — Monumental inscription to Painchsi, scribe of the treasury under Rameses II. Osiris written *with* determinative.

Nineteenth dynasty. — Monumental inscription to Pamerau, a royal scribe. Osiris written *with* determinative.

Twentieth dynasty.—Inscription on stela in museum of Marseilles. Osiris written *with* determinative.

These examples should prove fatal to any theory of a definite law observed in writing by the scribes.

The Aztec picture-writers, who came down to the ships of Cortez, could depict all they *saw*, but could not represent the sounds which they *heard*. At the time of Mena, B.C. 4400, the Egyptians could do both, and their writing *then* marked a distant transition period, combining the systems alphabetical and phonetic, with ideographs as determinatives, and these latter, with variants, were retained ever after. We may, I think, relegate the hypothesis of Herr Sethe to the same category as the non-historical existence of Solomon, who, on philological grounds, received his *quietus* at the hands of some critics, because Sol-om-on is found to comprise the name of the sun in three languages, forgetting that any name associated with the great solar myth, so dear to many ancient peoples, would naturally be treasured and handed down to posterity centuries after its original meaning had been lost, and its application passed into other forms.

In conclusion, it should be shown that it was the practice of the Egyptians to substitute new coffins at periods as required. Moreover, should they in any solitary instance be proved to have done so, it is inconceivable, with their intense veneration for the past, that the slightest alteration, even in form, should have been permitted in the reproduction.

On a glass shelf, immediately over the coffin of Amamu, are the remains of the mummy found by Colonel Vyse in the third pyramid, lying by the coffin-lid of Menkaura. That the fragments are portions of the body of Menkaura there can be little doubt. The integrity of these remains is in no way called in question by the contention of Herr Sethe. The leg bone of the mummy reveals a badly anchylosed knee, and, as tradition asserts that Menkaura was a lame man, this, in itself, is indirect evidence in their favour, apart from the fact of their discovery in the heart of the pyramid erected by that Pharaoh.

* Wilkinson's "Egypt."

† "Egypt's Place in Universal History," vol. I.

‡ "Receuil de Travaux," par M. Maspero.

ON THE PROBABLE ENCOUNTER OF BROOKS' COMET WITH A DISTURBING MEDIUM ON OCTOBER 21, 1893.

By Prof. E. E. BARNARD, *of the Lick Observatory.*

THE photographs of Swift's comet, made here in April, 1892 (see KNOWLEDGE for December, 1892), showed us what wonderful changes comets can pass through in a comparatively short time. Looking at these pictures, made on successive dates, it would be hard to convince anyone not familiar with the facts that they represent the same object at intervals of twenty-four hours. These enormous and remarkable changes, though they astonish us with their magnitude and rapidity, are nevertheless suggestive only of actual change in the comet itself, due to physical disturbances, the cause of which we do not yet know.

In examining these pictures, one looks to the comet alone for an explanation of the phenomena. There is no suggestion that any outside agency has had a hand in it, excepting, of course, the sun itself.

Another comet, however, has presented itself, of which an excellent series of pictures has been taken with the same lens used to take the photographs of Swift's comet over a year ago. This comet has passed through a series of changes that force one to adopt some other explanation to account for them than the physical peculiarity of the comet itself; and looking at the pictures of it, I cannot avoid the belief that the comet had nothing to do with the remarkable condition its tail got into, unless, indeed, it was to supply the tail to be interfered with by some outside and invisible influence.

The small comet discovered by Mr. Brooks, on October 16th of this year, was to all appearance, as examined with the telescope, a rather ordinary comet; a little below naked-eye visibility, and possessed of a tail that at best could only be traced for a couple of degrees with the aid of the telescope.

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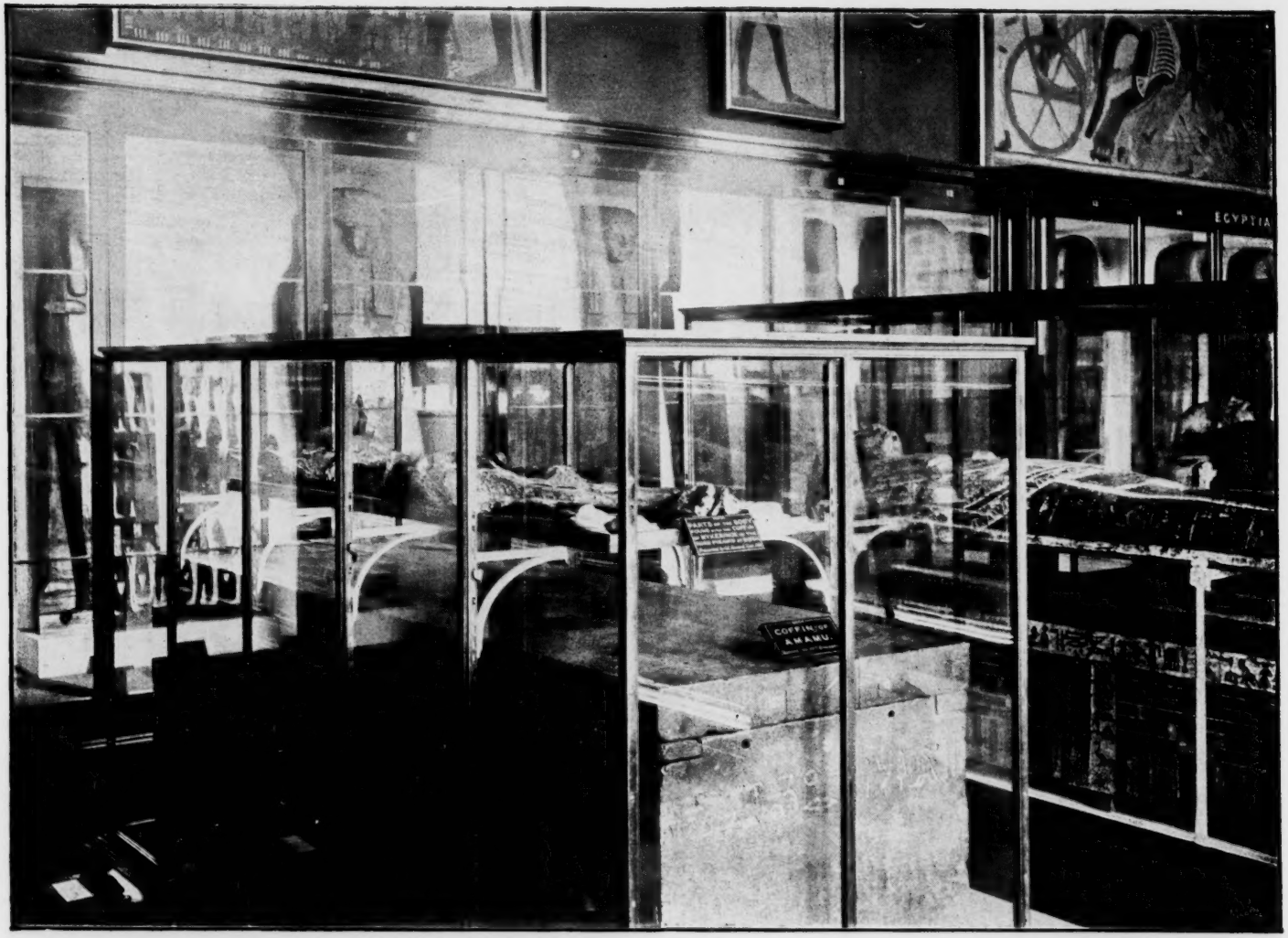

THE MUMMIFIED BODY OF KING MEN-KAU-RĀ, THE BUILDER OF THE THIRD PYRAMID, brought to England by Col. HOWARD VYSE, and now in the British Museum.

Reproduced from a Photograph taken by Mr. A. FISHER, of Southsea. The enlarged anchylosed knee of the shortened right leg is visible within the glass case on the shelf over the Coffin of Amamu.

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THE LICK OBSERVATORY IN WINTER. From a Photograph by Prof. S. W. Burnham.

The great white dome covers the 36-inch Refractor. The instrument with which the photographs of Brooks' Comet were taken by Prof. BARNARD is covered by the smaller dome, just below the dark dome covering the 12-inch Refractor at the extreme right of the Observatory buildings. The Lick Observatory is situated on the summit of Mount Hamilton, near San José, California, at a height of about 4000 feet above the sea.

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The great white dome covers the 36-inch Refractor. The instrument with which the photographs of Brooks' Comet were made is just below the dark dome covering the 12-inch Refractor at the extreme right of the Observatory buildings. The Lick Observatory is situated on the summit of Mount Hamilton, near San José, California, at a height of about 4000 feet above the sea.

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The comet was observed here with the twelve-inch refractor, on the morning following its announcement. Nothing seen during the measures of its position suggested that any phenomena of an extraordinary character would be recorded on the photographic plate; but the comet could only be examined for a few minutes before dawn would stop an exposure. It was, however, decided to try a plate the next morning, to see what might result from a short exposure. The time of dawn did not permit of more than half-an-hour, but the photograph was satisfactory and interesting, though it showed nothing of special interest about the comet, except that the tail was longer than had been expected from the eye view of it obtained with the twelve-inch refractor. The photographic plate also showed two small short "whisker" tails springing from the head of the comet, on each side the main tail (which itself was split along its axis into two strands). The morning of the 20th proved cloudy, but on the 21st another exposure was made to see if any change was taking place. No special change was noted, however, except that all the features were more strongly marked. The main tail, as before, was essentially straight.

The next morning the twelve-inch showed that some disturbance had taken place, for the tail near the head was distorted. An exposure was at once begun with the Willard lens. The resulting photograph was indeed remarkable (see the picture for October 21st). The tail now presented the aspect of a torch streaming in the wind. The appearance was precisely what we should expect had the comet's tail, in its flight through space, swept across or through some medium dense enough to break up the tail. I cannot see how anyone, comparing this with the picture of the 20th, can escape the conclusion that the tail did actually enter a disturbing medium which shattered it. This theory is, I think, further upheld by the third of these pictures, taken the following morning (see October 22nd), where the tail hangs in cloudy masses like the broken smoke train from a locomotive. In this last picture a large fragment is actually torn off and completely separated from the end of the tail. In the second photograph (see the picture for October 21st) the entire comet was brighter, as if the disturbance had added to its light, as also seems to have been the case with the third photograph on October 22nd, for its exposure was much shorter, as flying clouds were obscuring the sky a considerable portion of the time.

Unfortunately, cloudy weather and moonlight did not permit another exposure until November 2nd, when the comet's tail seemed nearly to have recovered its normal condition, except at its end, where a fragment stuck out almost at right angles, and on November 3rd it was to all appearances again straight; and thenceforward, though considerable changes of a physical nature were taking place, the comet did not again repeat the phenomenon of October 21st and 22nd.

In all, up to November 19th, I have secured sixteen photographs of the comet on fifteen different dates. On November 15th two exposures were given of ninety minutes each, in hopes of showing some rapid changes, but the comet was then in a quiescent state, and the two pictures are very much alike, Some of the exposures in the middle of November have been upwards of three hours long.

DESCRIPTION OF THE REMAINDER OF THE PHOTOGRAPHS.

I will give here a very brief survey of the different plates, following those already described, and which it is not possible to reproduce here.

On November 2nd the tail is about 4° long. It is irregular and somewhat curved. The end is abruptly turned through an angle of nearly 90°—a denser portion, about a degree long, projects abruptly from it towards the west.

On November 3rd the tail is almost straight and somewhat broader. The projecting mass is not shown—unless in an unrecognizably altered form.

On November 6th for 2° the tail is straight; for 2° more it is irregular and wavy; 6° from the head is a mass, one degree long, entirely independent of the tail.

On November 7th the tail is nearly straight, but somewhat irregular. It is 6° long. The detached mass is not certainly seen.

On November 10th the tail is 6° long. Very slender close to the head, then widens out in three distinct fans, the middle one being the main tail. A denser portion at the end almost detached.

On November 11th the tail is straight but irregular, and in several strands. A denser mass at the extremity. This plate shows a meteor trail parallel with the comet's tail and ·1° south of it.

On November 12th the tail is straight but slightly irregular. A detached mass $2\frac{1}{2}°$ from the end of the tail and south, and 8° from the head.

On November 13th the tail is short and brushy, with a faint straggling extension to Alpha Canes Venatici. This star is irregularly involved in a condensed mass of the cometary matter. A splendid meteor trail crosses this plate nearly parallel with the comet's tail, and 3° north. This trail is sharp and straight and very dense. It widens out as it left the plate, the meteor bursting in the sky a few degrees after leaving the plate.

On November 14th the tail is somewhat curved and irregular. There are two meteor trails on this plate—one a large one, cut across near the edge of the plate; the other is near Alpha Canes Venatici.

On November 15th the tail can be traced 10°. It is straight. There is possibly a denser mass at the end of the tail. The two negatives made on this date are essentially duplicates.

On November 19th the tail is straight; a thin or weak place occurs in it, nearly isolating the end.

Cloudy weather since this last date.

In nearly every one of these photographs there are small "whiskers"—I cannot better describe them—slender thread-like tails—that spring out on each side of the head, and which extend generally from $\frac{1}{4}°$ to $\frac{1}{2}°$ from the head, and are inclined at a considerable angle to the tail.

November 27th, 1893.

IRREGULARITIES IN THE TAILS OF COMETS.

By A. C. RANYARD.

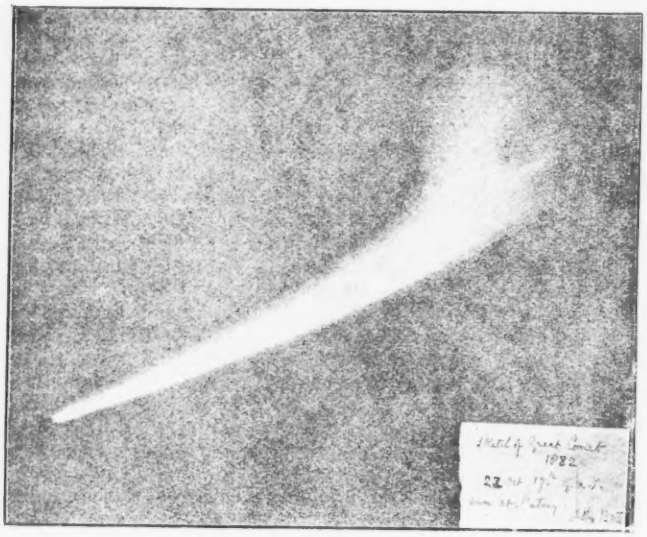
THE beautiful photographs of Brooks' comet, of which Prof. Barnard has kindly sent enlarged copies for reproduction in KNOWLEDGE, exhibit most striking irregularities of structure, which are well worthy of close study, for the observation of deviations from assumed general laws has frequently led to fresh discoveries.

As a general rule, in large comets the tail streams from the nucleus in a direction away from the sun, as if the matter of the tail was repelled by the nucleus and was also repelled by the sun; and when the tail is curved it falls behind the *radius vector*, or line joining the sun and the cometary nucleus, so that the curvature of the tail is concave towards the part of space which has been traversed by the comet, as if the particles of the tail retained their original orbital motion, but being driven into a larger orbit fell behind the radius vector.

XUM

But in Prof. Barnard's photograph of Brooks' comet, taken on the 21st of October, the general curvature of the tail is for some distance from the nucleus concave towards the part of space to which the comet was moving, while the fainter and more distant parts of the tail exhibit a general curvature which is concave towards the region from which the comet was moving.

If the reader will carefully compare the stars shown upon the photographs taken upon the 21st and 22nd of October, he will see that in the twenty-four hours which elapsed between the exposure of the two photographs the nucleus of the comet had moved in a northerly or north by east direction through a distance which corresponds to about seven-eighths of an inch on the scale of our plate. The two small stars which are shown on the photograph of the 22nd of October (the one to the east and the other to the west, at a distance of about one-eighth of an inch from the centre of the nucleus) will be found on the photograph of the 21st of October at a distance of about seven-eighths of an inch from the nucleus in a direction nearly coinciding with the line joining the nucleus with the upper left-hand corner of the plate.



Sketch by Mr. JOHN BRETT of Comet (*b*) 1882, made 22nd October. 17h. Greenwich mean time.

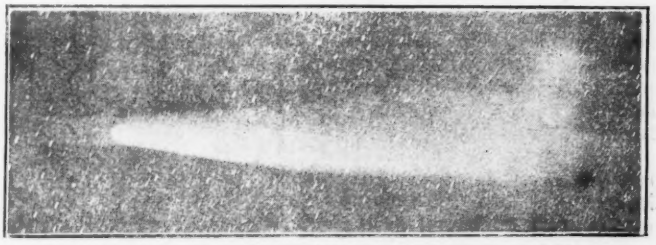
If the matter of the comet's tail was deflected in its course from the nucleus by an encounter with a resisting medium which was stationary in space we should expect to find evidence of resistance in a direction contrary to the direction of the comet's apparent motion; but though the advancing side of the tail is notched and sharply defined in the lower half of the tail, the opposite or following side is most sharply defined in the upper and fainter parts of the tail, and the following side of the tail is more sharply defined than the preceding side in the photograph taken on the 22nd of October.

As in the photographs of Swift's comet, published in the December number of KNOWLEDGE for 1892, there is striking evidence in these photographs of Brooks' comet that the matter of the tail was not driven away in a uniform stream from the nucleus. Prof. Barnard has noticed the detached cloud completely separated from the end of the tail on the 22nd of October, and the rest of the tail in the photograph taken on the 22nd of October is broken into fragments, indicating short spasmodic outbursts, during which matter must have been driven away in considerable quantities from the nucleus, followed by quieter intervals. That these outbursts were of comparatively short duration is, I think, proved by the slight curvature of the tail, which indicates that the motion of the nucleus was not considerable during the time occupied by the passage of matter from the nucleus to the end of the tail. On the other hand, the velocity of the matter of the tail away from the nucleus does not seem to have been sufficiently great to disturb the definition of the notches on the edge of the tail in the thirty-five minutes during which the photograph was exposed, on the 21st of October.

Such rapid changes in the amount of matter driven away from the nucleus would seem to point to an irregular evolution of energy, such as might be caused by the passage of the nucleus through an irregularly distributed resisting medium, or through swarms of meteors, rather than to the evaporation of matter due to a steady increase of heat on approaching the sun.

The notches and irregularities in the edge of the tail, as well as the branching structures in the photograph of the 21st of October, seem to me to point to outrushes of matter from the nucleus through a resisting medium, in different directions, which outrushing matter has afterwards been driven away from the sun, rather than to a disturbance of the regular form of cometary tail due to an encounter of the matter in the tail with a resisting medium at a distance from the nucleus.

The general form of comets' tails, and the way in which they develop in size as comets approach the sun, and diminish again as they recede from their perihelion position, points to the conclusion that the development of cometary tails is chiefly due to the action of the sun's heat; but the irregularities of form we are discussing point to more sudden changes, causing an irregular development of heat in portions of the nucleus, which gives rise to radial outrushes of gaseous matter in various directions. Such irregularities in the evolution of gas from the nucleus might be caused by collisions or internal disturbances in a loosely-piled group of stones, or cluster of meteors, on approaching perihelion; or it might be due to the rapid passage of external groups of meteors, or clouds of meteoric dust, into a loosely-packed gaseous envelope surrounding the cometary nucleus.



Comet (*b*) 1882, from a photograph taken at the Cape of Good Hope Observatory. (Undated.)

Though the earth does not encounter groups of meteors sufficiently dense to materially raise the temperature of large regions of its upper atmosphere, it does not necessarily follow that denser groups of meteoric stones may not exist in other parts of the solar system, and it must be admitted

XUM

XUM

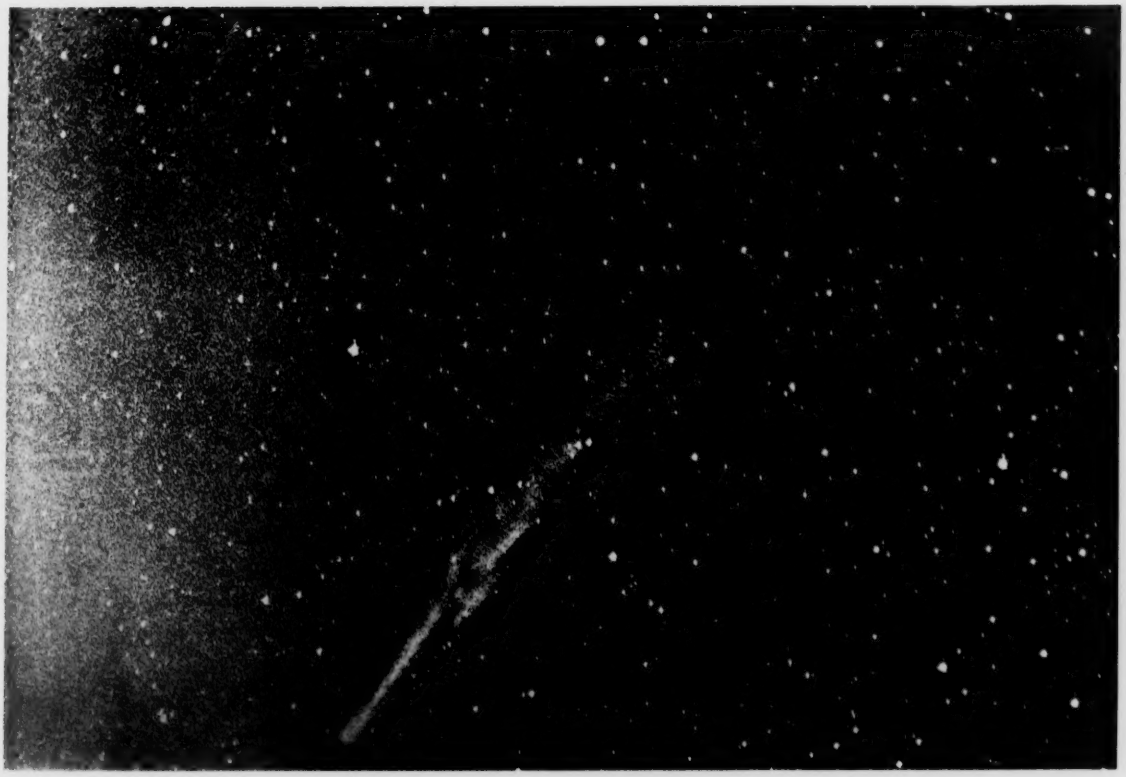
NORTH.

EAST.

WEST.

BROOKS' COMET, 1893, October 21st. Exposure, 16H. 37M. to 17H. 12M. Standard Pacific Time.

EAST.



WEST.

BROOKS' COMET. From a Photograph taken on October 22nd, 1893,

By Prof. E. E. BARNARD, with the Willard Photographic Lens of the Lick Observatory. Exposure, 16H. 30M. to 17H. 15M., Standard Pacific Time. Both pictures are enlarged from the original negatives about $2\frac{1}{2}$ diameters. Scale: 1 inch = 0·87°.

XUM

XUM

XUM

that the velocity of comets near to their perihelion distance is frequently large compared with the velocity of the earth in its orbit, and that the head or nucleus of comparatively small comets frequently greatly exceeds the earth in size, and would consequently sweep through a larger area.

But it seems more probable that the evolution of gas from a mass of stones, held together by the feeble action of their mutual gravity, may, as the mass is slowly heated, be sufficiently energetic to displace the stones, and thus bring fresh material to the surface to be acted on by the direct radiation of the sun.

If this is the case it would account for the irregularities in the structure of small comets being more marked than in large comets. For the larger the group of stones the greater would be the mutual attraction of its various parts, and the less would be the liability to its disturbance by the evolution of gas at a pressure corresponding to a given temperature; and the larger the group of stones the greater would be the density of the gaseous envelope surrounding it, and the greater would be the resistance to outrushes of gaseous matter from the nucleus.

We have at present diligently to collect facts. The branching structures shown in the photographs of Swift's comet, as well as the more striking branching structures shown in the photograph of Brooks' comet taken on the 21st of October, and the flattened heads of the small tree-like structures which project and form the notches at the eastern edge of the tail, present forms that remind one of the forms of solar prominences—that is, forms which are assumed by uprushing masses of gas passing through a resisting medium—and the conclusion pointed at, is that these similar forms have a similar origin, though spectroscopic and polariscopic observation of the light derived from comets' tails leads to the conclusion that the matter of which they are composed is not in the gaseous state.

The bright line spectrum seen in comets is generally only recognizable in the immediate neighbourhood of the nucleus, and the light from the tail is found to be polarized in a manner which indicates that its brightness is due to the light of the sun dispersed by a cloud of fine dust, the particles of which are on the average small compared with the wave-length of light. It would seem, therefore, that the gaseous matter evaporated from the nucleus is precipitated and then driven away from the sun in a cloud-like mass that retains the general outline or form which the gaseous matter had acquired during its outrush through the loosely-packed atmosphere surrounding the cometary nucleus.

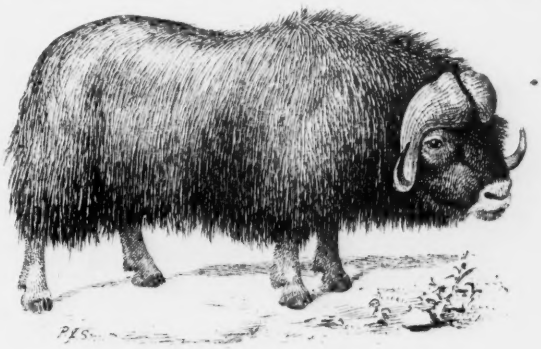
Even large comets have exhibited irregularities in their tails, notably the great comet of 1882 (*b*), in which the want of uniformity in the density of the cloudy matter of the tail was noted by several observers. I append a picture of this comet from a sketch by Mr. John Brett, which seems to be supported by the photographs obtained by Dr. Gill at the Cape of Good Hope with a portrait lens of two and a half inches aperture and eleven inches focal length. The mass projecting nearly at right angles from the end of the tail was noticed by several observers, while only a few noticed the faint veil of light shown in the photograph extending in a direction presumably towards the sun from the brighter parts of the comet near the nucleus.

Notice of Book.

Horns and Hoofs; or Chapters on Hoofed Animals. By R. Lydekker. London: 1893; 8vo, pp. 411. Illustrated, Horace Cox.—Mr. Lydekker's articles on big game, which have appeared during the last few years in the columns of the *Field* and *Land and Water*, have been very generally appreciated and we are glad to welcome their re-issue in volume form. In an ever-advancing science like zoology, progress is continually being made in our knowledge of animals, and we are glad to see that Mr. Lydekker has done his best to bring his chapters well abreast of the present time in regard to the numbers and characters of the species in the various groups treated of, though there are many groups left unnoticed. Thus the wapiti, and other horned animals of North America, are left without notice, and we look in vain for any description of such well-known animals as the European chamois, the American prong-horned antelope, the Rocky Mountain white "goat," and the extinct Irish elk.

It is obviously unreasonable to expect to find a complete treatise on horned and hoofed animals published in a series of articles intended for popular reading, but one may safely assert that no book which has hitherto appeared has contained such a complete list of horned and hoofed animals in the groups and regions treated of. The value of the work to naturalists would have been still further increased if Mr. Lydekker had given the various names or synonyms used by different authors in describing the same species. In a second edition he might, without detracting from the popular character of the book, give such synonyms in the index, with the authors who have used them, in chronological order, after the plan adopted by Sir Victor Brooke in his various papers on gazelles, sheep, and deer in the *Proceedings of the Zoological Society*.

In their original form, some of the chapters were not illustrated, but this deficiency has now been amended; while some of the figures which appeared in the columns



The Musk Ox (*Ovibos moschatus*).

of the *Field* and *Land and Water* have been replaced by new ones, in every way worthy of Mr. Lydekker and of the artists by whom they are executed. We notice, however, that there are still some outline figures which compare but poorly with the finished wood engravings; and if, as we hope it may, the book soon reaches a second edition, we would recommend the publisher to supply fresh ones.

Treating of the musk ox, which, as Mr. Lydekker points out, cannot be rightly classed as an ox, though its horns are at first sight so buffalo-like that the animal is almost always popularly regarded as a member of the bovine group, Mr. Lydekker remarks that, though in size and general appearance the musk ox recalls our smaller Highland cattle, its short tail, which is completely concealed among the long hair, and hairy muzzle, as well as the

structure of its grinding teeth (which in the upper jaw are narrow, and have no additional column on the inner side), prove it to be essentially a sheep.

One would have liked to hear Mr. Lydekker's speculations as to why animals having such different pedigrees as the musk ox and the buffalo should have developed horns of such similar character. Unlike the horns of other oxen and sheep, they cannot be detached from the skull. They spring from rugged flattened bosses which form a horny mass protecting the forehead, and then curve downwards, and afterwards upwards, becoming thin and cylindrical before they terminate in the sharp points which are used for offensive warfare. Two other animals of very dissimilar character, the takin of Assam and the white-tailed gnu of Southern Africa, both of which are antelopes, have horns of very similar form protecting their foreheads, though their habits, surroundings, and relationships are entirely different from those of the musk ox and buffalo. Only the male of the white-tailed gnu, the buffalo, and the musk ox, have these forehead protecting horns, so that probably they are of some service for fighting purposes.

The musk ox is an essentially Arctic animal, well adapted by its massive feet (of which the sole is in part hairy) for getting over the roughest ground with facility. They associate in small herds, which Mr. Lydekker states do not usually comprise more than thirty individuals. At the present day it is confined to North America, to the north of latitude 60°. Its range seems to be steadily becoming more restricted. Thus it was formerly common in Alaska, skulls having been obtained by Captain Beechey, during the voyage of H.M.S. "Blossom" in 1825 to 1828,

The Head of a Cape Buffalo (*Bos caffer*).

from the frozen deposits of Kotzebue Sound, in Behring Strait, and they have also been found on the upper part of the Porcupine River in Canada. Its bones have been found, together with human remains, as well as those of the bison and reindeer, in the Dordogne, and at a still earlier period, when mammoths existed in England, it was a resident here, indicating probably Arctic conditions at the time. While the musk ox only inhabits regions which are covered with snow during a great part of the year, the Cape buffalo is usually found in reedy swamps from the Cape as far north as the equator, but some individuals are found inhabiting heavy timber jungles. These, according to Mr. Drummond, have more widely spreading horns. Nearly all books of African sportsmen teem with anecdotes of hair-breadth escapes from the charges of buffaloes. The massive horny shield on the forehead of the old bulls renders their heads practically safe from a shot, though it is just possible to kill them by a well-planted bullet in the line of junction of the two horns. In the Pleistocene times the buffalo, known as *Bos antiquus* of the Cape, had horns with a stretch from tip to tip of at least fourteen feet.

In speaking of rhinoceros horns, Mr. Lydekker describes one in my collection as measuring forty and a quarter inches long and twenty-two inches in basal circumference, weighing thirteen pounds. I have since obtained one measuring forty and a half inches in length with twenty-nine and a half inches basal circumference, and weighing twenty-four and three-quarter pounds.

Treating of wild oxen, wild sheep, wild goats, the antelopes of Asia and of Africa, the deer of Asia and of South America, wild pigs, and rhinoceroses, the book covers a wide area of ground. It is written in a thoroughly popular style, combined with Mr. Lydekker's usual care and accuracy, and will be invaluable, not only to travellers and sportsmen, but likewise to the stay-at-home lovers of natural history who are interested in the study of the larger horned and hoofed animals which the sportsman speaks of as big game. Now that so many young Englishmen are making their home, either permanently or temporarily, in South and East Africa, the amount of information contained in the chapter on African antelopes, which cannot be obtained elsewhere in a collected form, ought alone to be sufficient to ensure the book a wide circulation. Both author and publisher are to be congratulated on the result of their efforts.

Edmund Loder.

Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

RETURNS OF PERIODICAL COMETS, AND OF 1881 V. (DENNING).

To the Editor of Knowledge.

Sir,—Mr. Lynn, in speaking of the "periodical comets due during the remainder of the present century" (see his work on "Remarkable Comets," p. 39, and article in Knowledge, vol. xvii., p. 7), appears to ignore the periodical comet which I had the honour of discovering on the early morning of October 4th, 1881. Mr. Lynn, however, refers to this object on p. 27 of his book, saying "the period was determined to be about nine years, but the comet has not been seen since, probably owing to perturbations as it approaches the paths of several planets." I would point out to Mr. Lynn that the comet returned *unobserved* to perihelion in 1890 in consequence of its singularly unfavourable position near the sun, and that we are by no means driven to the alternative of planetary perturbations to explain its non-visibility on that occasion. Presumably no one looked for the comet at its return in 1890 because no one expected to find it, as the ephemeris computed and published by Dr. Matthiessen showed that it must escape observation, being more or less in the glare of the sun during the few months when it was tolerably near the earth. The comet is, however, likely to reappear at the close of 1898 or beginning of 1899, when its more favourable position encourages the hope that it may be redetected.

Dr. Matthiessen predicted the time of perihelion passage in 1890 to be May 9th, and gave the probable error of his determination as less than four days. From this it would appear that the orbit of the comet has been computed with considerable precision, though the available observations of it in 1881 only extended over the fifty days from October 5th to November 24th. The exact periodic time was given by Hartwig as 8·8335 years, by Plummer as 8·8578 years, and by Matthiessen as 8·6874 years. Chandler made it less, while Block at Odessa made it more. Of the several values, Matthiessen's is probably the most accurate, as he utilized an observation at Strasburg, on November 24th, not known to the other computers. If we adopt his period of 8·6874 years (=8 years and 251 days), as correctly representing the mean period of the comet, then returns may be expected in January, 1899, September, 1907, June, 1916, February, 1925, October, 1933, &c.

Including a few comets omitted by Mr. Lynn as too uncertain, and adopting the periodic times given in *Astronomy and Astro-Physics* for November, 1893, I have compiled the following table of probable cometary returns up to the end of 1900 :—

1894, April,	Tempel (1873 II.)	1898, June.	Swift (1889 VI.)
1895, Febry..	Encke.	June,	Wolf.
June,	Barnard (1884 II.)	Septr.,	Tempel (1867 II.)
July,	Brorsen.	1899, January,	Denning (1881 V.)
1896, March,	Faye.	March,	Tempel (1866 I.)
October,	Brooks (1889 V.)	April.	Barnard (1892 V.)
1897, March,	Spitaler (1890 II.)	May,	Tuttle (1858 I.)
May,	D'Arrest.	May,	Holmes (1892 III.)
May,	Tempel-Swift.	July.	Tempel (1873 II.)
August,	Brooks (1886 IV.)	1900, Febry.,	Finlay.
1898, April,	Pons-Winnecke.	October,	Barnard (1884 II.)
May,	Encke.		

I have given the months of perihelion passage, but of course they are very doubtful in many cases. Their retention, however, serves to indicate the season. Wherever it seemed necessary to distinguish the comet by adding the year and number to the name, I have done so. The list shows that returns of periodical comets will be remarkably frequent in the last three years of the present century. For Tempel's comet (1866 I.) I have adopted Dr. Oppolzer's period of 33·176 years, but the mean period is probably a little longer than that, and corresponds with the 33¼ years of the Leonid meteors. Yours faithfully,

Bristol, January 8th, 1894. W. F. DENNING.

Re LARGE TELESCOPES.

To the Editor of KNOWLEDGE.

DEAR SIR,—In your interesting paper upon telescopes, in this month's KNOWLEDGE, you state that Lord Rosse's 6ft. mirror remains "the greatest light-grasping instrument which has been turned to the stars."

Surely, you forgot Dr. Common's 5ft. silver on glass reflector. There can be no doubt of its superiority as a light-collector over a 6ft. metal reflector. The highest estimate I have found for Lord Rosse's metal is that it returns 67 per cent. of the incident light. The second reflection at the flat will be ·67 × ·67, or ·45 about.

A silver on glass in good condition reflects 91 per cent., and its effective return after second reflection will be ·91 × ·91 = ·83 nearly. We compare the light-gathering power of the two instruments by multiplying the square of the diameters by ·45 and ·83 respectively then, which comes out as 161·6 for Lord Rosse's, and 207 for Dr. Common's, or the latter collects more than one-fourth more light.

It appears to me that neither large refractors nor large reflectors are quite satisfactory, but there is no doubt the American refractors have much better atmospheric conditions than our English reflectors.

January 5th, 1894. EDWIN HOLMES.

[Mr. Holmes is, no doubt, correct when he takes into account the loss of light on a second reflection at the surface of a flat. But the instruments may be used with a totally reflecting prism in place of a flat, or a photographic plate may be exposed in the principal focus.

When only the one reflection at the speculum is taken into account, Lord Rosse's instrument has the greater light-grasping power. Adopting Mr. Holmes' estimates for the percentage of light lost by reflection at perpendicular incidence from speculum metal and from silver, the ratio of light-grasping power would be as 36 × ·67 to 25 × ·91, or as 24·12 to 22·75.

In comparing the loss of light when a flat is used, it should be remembered that less light will be lost when the angle of reflection is 45° than when the light is reflected at nearly perpendicular incidence, as from a speculum, and that a silver on glass mirror tarnishes much more rapidly than a speculum metal reflector; so that in ordinary use a silver on glass reflector stands at a greater disadvantage, as compared with a newly-polished instrument, than a speculum metal reflector.—A. C. RANYARD.]

To the Editor of KNOWLEDGE.

DEAR SIR,—I beg to draw attention to a curious optical phenomenon, which seems to me worthy of more attention than it appears to have received.

When the eyes are fixed on a light at some distance, and partly closed, three pencils of rays, in the form of the letter Y, are usually seen apparently proceeding from it. One of the upper pencils disappears when the corresponding eye is closed, together with half of the lower pencil. Each pencil is seen to be made up of a varying number of separate rays.

I have found by experiment that the apparent arrangement of these rays varies remarkably, according to the structure of the eye of the observer. When the eye is normal the rays proceed directly from the luminous point of the flame; when myopic the rays cross each other and separate a short distance from the luminous point; when presbyopic the rays meet (or would if produced) beyond the luminous point. A concave or convex lens will enable anyone with normal eyes to see the appearances peculiar to presbyopic or myopic eyes respectively.

It is a curious fact that the arrangement of these rays in a particular eye is in fact a visible representation of the manner in which the actual rays reflected from outer objects traverse that eye, if we suppose the retina to occupy the place of the luminous point.

I suggest the following as a possible explanation :—The rays emitted from a luminous body, besides throwing an image of the body on the retina, have also the power of giving the sensation of an additional image, which takes the form of two pencils of rays proceeding from the luminous point. In a myopic eye the actual image as seen is badly defined, owing to well-known causes, and instead of a single image, a number of partly superimposed similar images are seen, each with its complemental pencils of rays. These rays cross each other and give the observed appearance. If a concave lens is now interposed between such an eye and the luminous body, and moved towards the eye so as to gradually correct its refraction, the images will approach, and form at length a definite image, giving two pencils of rays arranged exactly as in the normal eye. If the lens is brought still closer

the rays will now, of course, converge behind the retina, and, as before, a number of ill-defined similar images will be seen, each with its complement of rays. Bearing in mind the direction in which the rays now fall on the retina, it will be seen that the various pencils will combine to form two large pencils with foci lying beyond the images, as in the presbyopic eye.

An explanation of the cause of these rays would be interesting. J. Walter Brown.

Belfast, January 16th, 1894.

[The rays referred to by Mr. Walter Brown are well known. They are produced by the reflection of light from the wet surface of the edge of the eyelid when it partly overlaps the pupil of the eye; and thus they are only seen, as Mr. Brown remarks, when the eyes are partly closed. He may satisfy himself that the rays are produced by reflection from the edge of the lid by a few simple experiments.

If he entirely closes one eye and partly closes the other when looking at a distant candle, so as to see one upward and one downward ray, he will find that the lower ray is eclipsed if the edge of a visiting card is brought slowly downwards between the eye and the candle, and that the upper ray is eclipsed if the edge of the card be brought between the candle and the eye from below upwards.

If he obtains the assistance of a friend to watch the operation, he will find that he begins to lose sight of the end of the lower ray at the moment that the shadow of the card reaches the edge of his upper eyelid, and similarly with the upper ray when the shadow of the card reaches the edge of his lower eyelid. On inclining his head to one side, he will find that the rays revolve in proportion as the head is turned round; and by carefully laying hold of his eyelashes, and stretching or twitching the lid, he may alter the position and form of the rays.

These pencils of rays are, no doubt, the rays which artists intend to represent by the diverging lines they draw from the picture of a candle, but they do not correspond to the very numerous and fine bright rays which we see diverging from the images of brilliant points of light, such as electric arc lights, or the reflection of the sun from the bulb of a thermometer. These finer rays are seen when the eyes are wide open, and they are produced by radial inequalities in the structure of the crystalline lens of the eye—a curious structure grouped into six bundles or sectors, which is well shown in a picture in Helmholtz's "Physiological Optics" (see the French translation, p. 34).

The eyelids, when closing over the pupil, do not form a slit with parallel edges; and the two arms of the Y seen by Mr. Brown seem to indicate that while the edges of his upper eyelids are parallel, the edges of his lower eyelids are inclined to one another.—A. C. Ranyard.]

ENCKE AND SEEBERG.

To the Editor of Knowledge.

Sir,—We have all heard of the complaint of Socrates that Crito confounded him with his corpse by asking him how he wished to be buried. By a stranger, or at any rate more unusual mistake, your readers this month must have thought that I had confounded Encke with his dwelling-place during the early part of his astronomical career. But what I wrote (p. 7, col. 1, line 20) was not "the illustrious Seeberg, an astronomer," but "the illustrious Seeberg astronomer," Encke having been at that place when he determined the orbit of the comet with which his name is indissolubly connected.

The Seeberg Observatory, founded by Duke Ernest II. in 1791, was situated a few miles from Gotha. Zach and Lindenau were successively directors of this establishment, where Encke laboured from 1815 until he was appointed director of the Berlin Observatory in 1825. The building at Seeberg had fallen into decay, and the instruments were transferred to a new observatory, erected at Gotha, in 1857, where Hansen, Encke's successor, remained until his death in 1874.

Yours faithfully,

Blackheath, Jan. 1st, 1894. W. T. Lynn.

THE ASTRONOMICAL SOCIETY'S MEDAL.

The Council of the Royal Astronomical Society have this year awarded their gold medal to Mr. S. W. Burnham, who has long been acknowledged as *facile princeps* of double star observers. He is not only a very keen-eyed observer, who has detected nearly all the very close and most difficult double stars that are known, but he has discovered more double stars than Sir William and Sir John Herschel, Wilhelm and Otto Struve, and Dembowski put together, and has made a most exhaustive study of the history of double star observation, which has enabled him, by a comparison of the observations of all the well-known double star observers with his own observations, to determine with far greater accuracy than was previously possible the forms of the apparent orbits of all the principal binary systems. Sherburne Wesley Burnham was born about 1840 at Thetford, Vermont, U.S.A. His first discoveries were made with an excellent six-inch refractor, made by Alvan Clark. Subsequently he worked with the eighteen and a half inch refractor of the Dearborn Observatory, Chicago, and then with the thirty-six inch refractor on Mount Hamilton. He retired from the Lick Observatory some two years ago, but he has now been appointed to the Yerkes Observatory, where he will have ample opportunities of using the forty-inch refractor.

STINGING INSECTS.—I.

By E. A. Butler.

Amongst the varied powers possessed by insects, there are, perhaps, none that have made so forcible an impression upon the human mind as that of stinging. The intensity of the pain that follows a sting, contrasted with the insignificance of the being that causes it, and the quietness, suddenness, and unexpectedness of the operation, whereby there is no time left for the person attacked to put himself on his guard, or to prepare for defence, are circumstances well qualified to inspire caution. To facts like these may, no doubt, be attributed the very prevalent feeling of suspicion with which unknown insects are regarded, especially if they have a formidable appearance. In consequence of this widely-diffused distrust, many insects that are perfectly harmless are popularly credited with venomous powers, especially if their shape or general aspect suggests such a property. The prejudice thus created is most difficult to eradicate. It begins in the nursery. Children when quite young are cautioned against creatures that could in no way harm them, and this influence descends from one to the other as part of the inheritance of nursery traditions; the error is thus perpetuated, and shows at times such extraordinary vitality that the strongest assurances of experts are insufficient to dispel the illusion. And yet a very little general knowledge of insect structure is enough, without any close acquaintance with particular species, to enable an ordinary person to judge for himself whether any given insect is a stinger or not. We propose in this paper to

endeavour to make clear what insects really are venomous, and what is the true nature of the stinging operation, as well as to say a word on behalf of some that are commonly, but calumniously, regarded as dangerous.

Confining our attention to the fauna of our own islands, we may state, in the first place, that the number of species possessed of this power of annoyance bears an extremely small proportion to the total insect population. The power is not indiscriminately distributed, but is confined to certain special groups; so that if one can only acquire a general knowledge of insect types and a readiness in the art of classification, or recognizing at a glance the order or sub-order to which an insect belongs, it becomes a very easy matter to estimate on *à priori* grounds the chances of its being a stinger. Whole orders, containing thousands of species in our own country alone, may be dismissed at once as including no members that indulge in the objectionable practice. But before indicating which they are, it will be necessary to define somewhat carefully what is to be understood by the word "sting." It is popularly used for at least four operations, which differ more or less widely from one another. The truest sense is doubtless that which implies (1) the making of a puncture, for offensive or defensive purposes, by means of a sharp-pointed and complex organ which is the equivalent of what in other insects becomes an egg-laying instrument, and is therefore placed at the *hinder* end of the body, and (2) the injecting into the wound thus made of some poisonous liquid secreted by the insect itself. The injection of an irritant poison easily explains the intense pain and other discomforts that follow such punctures. But in some cases a puncture is made defensively by a sharp-pointed instrument in the same position as above, but no poison is injected, since the gland necessary for its secretion is absent. Here no swelling or discomfort follows, and the only pain that is felt is the sharp prick at the moment when the puncture is made. By those who are unfamiliar with the insects, this would be at first regarded as a sting, for pain and inflammation are naturally expected to follow a sharp puncture, and it is only when the effect is found to be transient that the difference between this and the true sting can be discerned.

The third kind is that in which a puncture is made by a combination of fine perforating instruments which constitute the mouth organs, and are therefore situated at the head end of the body. In this case, as we have pointed out on previous occasions, it is a moot point whether any poison is instilled or not, no special poison glands being discoverable, unless the saliva itself possess an irritating property; but however that may be, the operation is obviously one of a totally different character from those before mentioned, and its purpose is not essentially offensive or defensive, but consists merely of an endeavour to obtain food, though on occasion, possibly, use may be made of it for protective purposes as well. The two first mentioned, as being purely strategic actions, so to speak, are accomplished quickly by a sudden rapid plunge with a hard and stiff weapon; but the third is a slower process, and usually consists in forcing a collection of exceedingly thin and flexible hair-like organs gradually through the skin. This also is often followed by painful swellings and inflammation. All the actions already enumerated are more or less under the control of the insects themselves. But to these must be added those cases in which painful swellings are caused by the mere handling of the insect, through accidental contact with its glandular hairs, a species of injury unintentional and entirely beyond the control of its inflictor.

Under one or other of the above four heads may be arranged all the instances that may reasonably be described as stinging, by whatever insect the injury may be inflicted. Under the first head come the true vengeful stings, such as those of bees, wasps, and ants; under the third, the punctures made by bugs, gnats, and other flies, in their efforts to obtain the liquid food on which they subsist; flea-bites also may be ranked here, although there is some modification in the shape of the organs concerned. Thus, when we speak of the "sting" of a wasp, and the "sting" of a mosquito, we are referring to two totally different operations carried out by instruments placed at opposite ends of the body, and for totally different purposes—the one a fighting, and the other a feeding action; the one for forcing down poison into a wound, the other for sucking up blood out of a wound. Aristotle, and after him Pliny, long ago pointed out this distinction, showing also that the tail-stingers, such as bees and wasps, were *four* winged, but the *mouth*-stingers, such as gnats and flies, *two*-winged. Under the second head will be included any punctures that may be made by ichneumon flies, which are the most insignificant of all in their effects; and under the fourth, those painful swellings that are caused by the hairs of the caterpillars of certain moths, such as the gold-tail and brown-tail described in a recent paper, and the processionary moths of the Continent. This fourth group, again, differs from all the rest, in that the power of stinging is possessed by the insect in its larval condition, whereas in all the other cases it pertains only to the adult.

FIG. 1.—Antennæ of Hornet: A, male; B, female. Magnified two diameters.

We are now in a position to consider, from the systematic point of view, what insects those are that possess the stinging power in either of the senses described above. All insects that can voluntarily inflict punctures, whether distinctly poisonous or otherwise, with mouth or with ovipositor, are included in three only out of the eight or nine orders into which almost all insects are grouped, viz., the Hymenoptera, to which bees, wasps, and ichneumon flies belong; the Diptera, containing gnats and other two-winged flies; and the Hemiptera, or bugs. Thus we may dismiss from our thoughts altogether the following groups, as having no share in the opprobrium that rests upon the orders just mentioned: the order Coleoptera, containing over three thousand British species, which consist of beetles of all sorts, including many that have other popular names, and are not usually called beetles, such as ladybirds, glow-worms, weevils, cockchafers, and the like; the Lepidoptera, or butterflies and moths, with over two thousand British species, if we except the two or three whose caterpillars have irritating hairs; the Neuroptera and Trichoptera, or dragon flies, lacewing flies, and caddis flies, a total of between three and four hundred; the Homoptera, or frog-hoppers and plant lice, containing some hundreds of species; and the Orthoptera, or earwigs, cockroaches, crickets, and grasshoppers, a group feebly represented in this country, and including only between forty and fifty species. Here, then we have a total of some six thousand British insects, to none of which does the charge of stinging apply. But this is by no means all, for of those three orders mentioned above, which contain the stingers, the Hemiptera (excluding the lice) yield only some half dozen, out of their total of nearly four hundred and fifty British species, against which the charge can in any way be substantiated; the flies only a small proportion of their total of over three thousand; and even the Hymenoptera, which contain most of all, probably not much more than an eighth of their four thousand or upwards. Hence it appears that, were it not

for the fact that some of the stinging insects are amongst the commonest of the common, and that enormous numbers of specimens of them are to be found, we might, in consideration of the small proportion of the total number of kinds that are thus harmful, expect not very frequently to meet with any that would on this score justify distrust.

In the above list of non-stingers, the only ones that call for additional remark are the dragon flies. These large, rapacious, and usually powerful insects have, unfortunately, acquired a very bad name, and have a widely extended reputation for stinging, which is, however, nothing more than mere tradition, and has no foundation in fact. The popular prejudice against them is crystallized in the common names of some species, such as horse-stingers and devil's darning needles. The long, thin body, which is often twisted about as if in search for an object to attack, is, no doubt, partly responsible for the origination of the idea of their venomousness. Nevertheless, the idea is absolutely incorrect; as one writer has said: "In both its states of water and air, it can do everything wicked except the one thing it is popularly supposed to do best, namely, *sting*." No stinging organs are possessed by any species, and no power of doing direct injury to human kind exists amongst them, so that no one need fear handling any kind of dragon fly. The only possible suggestion of harm is in the jaws of the larger kinds, these being powerful (relatively), so that they can inflict a sharp pinch, but still not enough to pierce the skin.

Turning now to the Hymenoptera, as containing those insects that most truly merit the epithet "stinging," we find a special section of the order, to which the name of Aculeata, or sting-bearers, has been given just because they differ from the rest of their kindred by the possession of a poisonous sting. This section contains several sub-divisions, such as the ants, the fossores or digging wasps, the true wasps, both social and solitary, and the bees—these, too, including both social and solitary species. As the sting is a modification of the ovipositor, or instrument for depositing the eggs, it is of course found only in the females; hence none of the males of the above insects are able to defend themselves by stinging, but may all be handled with impunity. Their longer, thinner body, and longer antennæ (Fig. 1) will often distinguish them; but sometimes they are totally unlike their partners, and therefore it is hardly possible to lay down general directions for recognizing them. In those species that are social the sting is carried not only by the true females, who are often few in number, but also by that curious and very numerous intermediate or third form which is characteristic of social insects, viz., the workers, who are a sort of abortive females. When, then, we speak of being stung by wasps or by the hive bee, it is almost invariably the workers who are the guilty parties. The only female in a bee-hive is the queen, and she is not met with in the open except at the time of swarming. Amongst the wasps, the females, or queens, are more likely to be met with, but they are far outnumbered by the workers. Amongst the ants, a certain family, the *Formicidæ*, are not provided with a usable sting, but merely with a rudimentary representative of that organ, though the poison gland is well developed and contains poison in abundance; this they eject at their foes with considerable force and to great distances, and as it is of a strongly acid character, it causes a smarting sensation on a sensitive skin, especially if injected, as often happens, into wounds already made by their jaws.

To illustrate the structure of the sting, we may take the instrument as found in the largest species, as, for example, a hive bee, a humble bee (Fig. 2), or a wasp (Fig. 3). The plan is the same in all, with differences of detail only. When not in use, the whole of the sting apparatus is withdrawn between the pair of terminal plates of the body, which open like a mouth to allow of its extrusion. These must be removed before it can be seen; they can easily be torn off with a fine pair of forceps. The sting now stands revealed, and its most prominent part, which will be at once detected, is a strong dart, straight or curved according to the species; it is grooved on its under surface, and tapers to a not very sharp point. At its upper end it is expanded into a broad, pouch-like body, and both this and the greater part of its narrower continuation are double-walled.

FIG. 2.—Sting of Humble Bee. Magnified fourteen diameters.

Within the groove lie two long, narrow lancets, which can be moved up and down in the dart, by running along two projecting lines like rails, which extend from top to bottom of the groove; they are worked by levers and muscles attached to their upper ends. The lancets are notched at the free end with teeth that point backwards, like the end of a savage's spear; throughout their length they are hollow, but their cavity communicates with the exterior by a little channel amongst the barbs. In communication with the pouch at the top of the dart is a membranous tube, which is connected with a thin-walled bag, the poison receptacle. From the upper end of this bag there passes a long, white, thread-like, coiled tube, which soon divides into two branches, each of about the same diameter as the undivided tube, and these ultimately end blindly in little knob-like swellings. The poison, which consists largely of formic acid, is secreted within these tubes, and is poured from them into the bag at the base of the sting, where it is stored till required. Close by the base of the sting there is a pair of hair-beset feelers, called collectively the sting-sheath, and intended to assist in guiding the dart to a suitable spot for attack.

In the act of stinging, the dart and its feelers are first thrust out between the terminal plates of the body, and the dart is pressed against the object attacked, so as to enter the skin; the lancets are then slid along their rails and pass out beyond the tip of the dart, thus making the wound deeper; at the same time poison passes from the bag in which it is stored, down the groove in the dart, and out at its extremity into the wounds; but some also finds its way into the interior of the lancets themselves, and so out through the channel near their tip, and thus into the wound at a deeper point. The recurved barbs on the lancets and dart of course operate as a drag in any attempt to withdraw the sting, and it is entirely a question of the relative strength of resistances whether the sting can be withdrawn or has to be left in the wound. Thus

when the insect is alarmed and tries to pull out its sting suddenly, as is of course usually the case when, for example, a bee stings a human being, it often happens that the sting cannot be extricated quickly enough, but the bee in its struggles tears itself away, leaving the sting and all its appendages still sticking in the wound. According to Mr. J. D. Hyatt, if a bee be allowed to sting a soft piece of leather, it will be unable to withdraw the sting, and will tear itself away, leaving the whole apparatus beautifully dissected out, while the insect itself will fly away, apparently not seriously incommoded by the loss. It is stated that the queen bee is not very ready to use her sting against human kind, reserving it for despatching her rivals; and that when she does sting a human being, she is able to withdraw her sting more easily than a worker, by turning round on it as an axis, and so giving the instrument a corkscrew motion. Much of the muscular movement connected with the act of stinging seems to be of a reflex nature, so that it may take place some little time after the death of the insect, and it is the painful experience of most persons who incautiously handle dead wasps to find that death has not robbed them of the power of stinging.

With bees, whether solitary or social, the use of the sting is evidently, since the insects are entirely vegetarian in diet, merely a means of defence against enemies; but with the rest of the aculeate Hymenoptera the case is somewhat different. Wasps are hunters, and expert ones too; their young are reared on animal food, and the workers therefore hunt for prey to satisfy these claims. The sting here comes in very usefully as giving them an easier victory over the quarry, and as rendering it, when caught, powerless to interfere with its transportation to the nest. The same remark applies to ants. The fossorial Hymenoptera are somewhat differently circumstanced. Though a numerous group, they are not generally well known, and therefore have no popular names other than that of sand-wasps, which they share (wrongfully) with the solitary wasps. As their technical name implies, they are diggers, burrowing into the earth, or into wood, and they have a preference for sandy places, where the soil is easier to excavate. Each burrow is formed by one insect, and tenanted by one brood only, for they are solitary in habits, *i.e.*, the species consist only of males and females, and each female makes a home for her own brood alone; the young, therefore, do not depend upon the care of nurses, but are left entirely to themselves, and have to feed themselves from the moment of their liberation from the egg till they become pupæ. Nevertheless, they do not collect their own food, but a supply is provided by the mother before they are hatched. Thus, as they never need to leave their birth-cell, they can afford to do without legs, which would, in fact, only be in the way within the narrow confines of the cell; consequently, these larvæ always take the form of footless maggots. When the mother has made the cell, her next business is to begin to provision it. The larvæ are carnivorous, feeding upon caterpillars, flies, gnats, spiders, aphides, beetles, &c., the particular creature selected depending upon the species of fossor. Each species usually confines itself to one sort of prey; the mothers are, in fact, very good entomologists, able to distinguish the right kind of creature amongst the multitude of species of all kinds that they meet with in their explorations, and often far more keen in knowing how and where to get hold of a particular sort of insect than most human collectors. In proceeding to provision the cell, then, the mother hunts up a specimen of the proper sort of prey, deposits it in the cell, and then lays an egg upon it. A store of provisions of the same sort must now be got together in sufficient quantity to last the larva its whole lifetime, and there is also the further requirement that it must be in such a condition as to remain fresh, and neither dry up nor become putrid so long as the grub has any need of it. The sting enables the mother to make the necessary arrangements without difficulty. The prey, if thin-skinned, such as caterpillars, is often stung slightly when caught, enough to prevent it from struggling, but not so much as to quite kill it. In this condition it is stored up, too helpless to escape, but at the same time with as much vitality left as will serve to keep it soft and fresh, and prevent it from shrivelling up or becoming mouldy. Hard-skinned insects, such as beetles, are stung to death before being put beneath the ground; then the dampness of the soil softens their joints, so that by the time the grubs are ready to proceed to the feast, the feast has been reduced to a proper consistency for their jaws. The number of corpses, or semi-animate bodies, with which the larder is stocked of course depends upon the size of the insect to be reared as well as upon that of the prey itself. For a certain large species, which is shaped a good deal like an ichneumon fly, a single large caterpillar suffices; in other cases, a dozen or so of small spiders, or some fifty or sixty aphides, may be found piled up in a cell. Most of these fossorial Hymenoptera are smaller than the generality of bees and wasps, and hence their sting, though fatal to their legitimate prey, has generally but a trifling effect upon ourselves; in fact, several species are extremely reluctant to use their sting at all when handled.

Fig. 3.—Sting of Wasp: *a*, dart; *b*, lancet, escaped from groove; *c*, poison bag; *d*, feelers; *e*, base of poison gland, the rest having been removed. Magnified ten diameters.

(*To be continued.*)

FOSSIL WOOD.

By the Rev. A. S. Wilson, M.A., B.Sc.

A DELIGHTFUL experience awaits the botanist on turning his attention to fossil plants. Entering the realm to which palæontology introduces us, forms of singular elegance and beauty greet the eye; others are seen, strange and grotesque, which bid defiance to all our previous conceptions. No one who is not altogether destitute of imagination can contemplate the exquisitely graceful outline of Sphenopteris, or the ornately sculptured stem of Ulodendron, in fairly preserved specimens, without catching a glimpse of this fairyland of palæontology.

We gain but an imperfect conception of any plant, however, from its external appearance alone; for its proper comprehension we must also know something of its life-history and internal anatomy. This presents little difficulty in the case of the leaves, buds and flowers enclosed in the amber obtained from the Eocene strata of Germany. Models of flowers belonging to the chocolate order, with all their parts perfect, have been obtained by forcing melted wax into certain cavities in the Tertiary tuffs near Sezanne, in France. But without recourse to any expedient of this kind Renault procured from the Carboniferous strata of

Grand Croix silicified flowers, in which the pollen grains contained in the anthers, as well as the details of the structure of the seed, could be readily discerned. Such materials enable us to trace the entire life-history of a number of fossil species. Rarely, indeed, are all the characters of the original plant retained by the fossil; a very vivid idea of extinct vegetable life can, fortunately, be obtained from the microscopic examination of specimens in which the minute structure of the tissues has been preserved. As a rule, it is only in true petrifactions that this occurs. From casts, moulds or impressions which constitute the great bulk of fossils the original substance has, for the most part, been removed; what remains is generally the merest film of carbonaceous matter in which no structure can be detected.

In coal, again, the mineralizing process has usually gone so far that the structure of the plants out of which it was formed is almost entirely obliterated. By subjecting exceedingly thin slices of coal to the microscope, Reinsh, however, detected even in anthracite evident traces of the tissues of the higher plants. From most kinds of coal, Schulze also, by maceration in petroleum, soda and other reagents, was able to separate organic fragments showing all the structural elements of wood. Wigan cannel coal and many other gas coals and lignites plainly reveal their vegetable origin, and from Bradford and Fordel collieries samples have been described consisting entirely of the spores and spore-cases of ferns. But our knowledge of the internal structure of extinct plants is mainly derived from fossils, which have resulted from the petrifying action of carbonate of lime or silica held in solution in water.

At the present day, springs and other natural waters possessing this petrifying power are of frequent occurrence, especially in limestone and volcanic districts. In the vicinity of some of the geysers of the Yellowstone Park of North America, for example, trees, still erect, in all stages of petrifaction may be seen; grasses, reeds and ferns are converted into stone round the hot springs in the island of St. Michael, and similar phenomena occur in many other localities. Subjected to the action of a petrifying spring, the substance of a plant is gradually removed, and as each particle dissolves it is replaced by a particle of carbonate of lime or flint, as the case may be. Now this transformation, which we can observe in operation, has occurred very largely in past geological time. The astonishing thing about this process is, that under favourable circumstances the exchange of material is effected without appreciably altering the structure. Polished sections of completely silicified palm stems from Antigua may be seen in many museums, in which, with the unaided eye, all the details of the endogenous structure can be easily recognized. Specimens of exogenous stems similarly preserved are also met with, exhibiting the pith, annual rings, and bark, almost as perfectly as a newly-felled tree. From the lower Eocene of Herne Bay, Carruthers obtained a silicified fern allied to Osmunda, in the cells of which, not only were the starch grains still visible, but traversing the petrified tissues could be clearly traced the mycelium of a parasitic fungus. More remarkable still, when thin sections of petrified wood are examined with the microscope, we find in many cases that its constituent cells not only retain their distinctive shapes, but the markings on the cell-walls are faithfully reproduced. Annular, spiral, reticulated, scalariform, pitted, and border-pitted markings, even the excessively fine cross striæ, may be seen as distinctly in the fossil as in sections of fresh plants. Nor is it only thick-walled, lignified cells that are petrified; even the delicate, thin-walled, transparent cells of the cambium layer are often as plain as in a section of living wood. This is the less surprising in view of what happens in the Equisetaceæ and other plants containing much silica. The horsetails are practically silicified while still living. The Charas and Corallines might also be described as living fossils, since they petrify as they grow.

The oldest plants of which the structure is known are Algæ from the Silurian strata of Wales. Silicified woods found by Dawson in the lower Devonian of Canada are by him referred to Coniferæ, but by Carruthers to the Algæ. Hugh Miller discovered wood resembling that of Coniferæ in the lower Old Red Sandstone of Cromarty. Wood of similar character occurs in the middle and upper Devonian, but is much more abundant in the coal measures. Oldham and Halifax are among the more noted English localities. Specimens have also been obtained from Granton and Craigleith quarries, from Coldstream, and Laggan Bay in the island of Arran, where some years ago Wünch discovered a number of stems with well-preserved structure. The volcanic deposits at Burntisland have also yielded considerable quantities. The Fife and Arran plants are referred to the genus Lepidophloios; they have excited considerable interest among British and foreign geologists. St. Etienne and Autun in France, Chemnitz and Dresden in Germany, are among the most noted localities on the Continent. Of the Secondary or Mesozoic formations the oolite is richest in plant remains. Pinites occurs in this formation in the island of Eigg, and Hugh Miller states that cartloads of oolitic wood have been removed from the shore at Helmsdale and burnt for lime.

The Portland dirt-bed, with its remarkable assemblage of fossil cycads, also belongs to the oolitic series. Cretaceous rocks in Greenland contain abundant remains of vegetation; woody tissue even occurs occasionally in the flint nodules of the chalk, and the Tertiary strata are particularly rich in fossil plants. Even forests of petrified trees are met with in some parts of the world, such as the eastern coast of Australia, Tasmania, near Cairo, and in several other places. In some of these the structure of the wood has been preserved; in others, as in the fossil grove at Whiteinch, it has disappeared.

Fossil wood thus occurs more or less plentifully in all formations except the earliest. The chief interest attaches to examples obtained from the older or palæozoic rocks. Most of these show a remarkable uniformity of structure and greatly resemble the wood of the araucaria or Chili pine. Wood of this type is known as araucaroxylon. From its coniferous character and abundance in Carboniferous strata the older geologists were led to infer that cone-bearing trees had been very plentiful during the coal period. This is now known to be an error, for although true conifers existed in palæozoic times, their remains only occur sparingly in Carboniferous and Permian rocks. Wood of the araucarian type is now known to have been produced very largely by the Cordaitæ, an extinct family of plants at one time thought to be monocotyledons on account of their grass-like leaves, but since proved to have the closest affinity with the Cycadaceæ.

As we should naturally expect, it is the harder and tougher portions of vegetable tissue that most frequently appear in petrifactions. The internal substance of a fungus, seaweed or other thallogen, is entirely cellular. If we slice the stalk of the common tangle it is found to present a uniform appearance, and to admit of being cut with equal ease in all directions. On cutting across the root-stock of a fern, on the other hand, the knife encounters a circle of stiff fibres embedded in the softer substance. These are the fibro-vascular bundles; they run in a vertical direction through the stem, uniting laterally at

intervals, and forming a kind of internal framework. By scraping away the softer substance, a beautiful hollow cylinder of network, the fibro-vascular system of the fern, is exposed. This system, present in all the higher plants, assumes characteristic forms in the leading divisions of the vegetable kingdom. In the stem of a palm or other monocotyledon the fibres are irregularly scattered through the cellular substance; the softer part being in the centre, this arrangement is termed endogenous. The stems of dicotyledons and conifers, on the other hand, are exogenous and show a central pith surrounded by rings of wood and layers of bark. The young exogen has a ring of five bundles or so, reminding us of the adult condition of the fern stem, but every succeeding year a fresh ring of secondary bundles is formed towards the outside; the primary bundles at the same time greatly increase in diameter, so that very soon the vascular system in the exogen assumes much greater importance than it has in the fern, and ultimately constitutes the great bulk of the stem. Cellular ground tissue occupies all the space enclosed by the epidermis which is not taken up by the vascular framework. The ground tissue includes the pith, most of the bark, and the medullary rays. The last mentioned are vertical plates of tissue which pass from the pith to the bark, separating the bundles, and penetrating the meshes of the vascular system; to them is due the appearance known as the silver grain of wood, easily recognized even in fossil specimens. The primary vascular bundles formed during the first season are the only ones ever developed in ferns. Dicotyledons and Gymnosperms are the only living plants in which secondary thickening occurs. By this is meant the increase of thickness that occurs after the part has ceased to grow in length. A certain length of stem is produced during a season of growth. In ferns and palms this portion never becomes any thicker; the trunk of an exogen like the oak, on the other hand, increases in girth as long as it lives. With the single exception of Isoëtes, in no existing fern, club-moss, horsetail, or other Cryptogam does secondary thickening take place. The extinct Lepidodendron and Calamite differed in this respect very widely from their modern representatives. Williamson has shown that they possessed the power of forming secondary wood by exogenous growth. The loss of this power may perhaps account for the diminutive proportions of existing Lycopods and Equisetaceæ, to which the arborescent Lepidodendron and Calamite of palæozoic times were closely allied.

The separation of the secondary wood of exogens into rings is due to a difference between that formed in autumn and the portion added in spring; the autumnal wood is dense, the vernal is of looser texture and consists of larger and more delicate cells. This is, however, only the case in temperate climates where the seasons are marked. In tropical woody plants annual rings are not, as a rule, distinguishable. As indicating the former extension over the globe of a more uniform and tropical climate, it is interesting to note the entire absence of yearly rings in the fossil woods of the palæozoic strata.

The stem of Lepidodendron, though agreeing with that of an ordinary exogenous tree as regards the formation of secondary wood, was in other respects very dissimilar. In succulent and herbaceous plants the ground tissue preponderates over the vascular system, and Lepidodendron partook somewhat of the herbaceous character. There was a central axis or cylinder of small diameter relatively to the stem, consisting of a ring of wood which varied in thickness with age. Inside, the woody ring enclosed an enormous pith; outside, it was surrounded by a bark or cortex of great thickness. The bark of most trees is thin compared to the woody part, but the rind of Lepidodendron occupied in many cases quite four-fifths of the diameter of the stem. It consisted of three layers; the innermost had a delicate spongy character, and is rarely preserved. Of this tendency of the inner cortex to degenerate we have an extreme example in the modern Selaginella, in which the central axis is separated from the cortex by a vacant space traversed here and there by delicate horizontal cells or trabeculæ. In various members of the Lycopod family, Prof. Bower has recently found this inner layer of the rind to exhibit transition stages intermediate between the conditions in Lepidodendron and Selaginella. To compensate for the weakness of the vascular system, the outer cortex in many extinct Cryptogams was strengthened by strands of schlerenchyma, consisting of thick-walled cells forming the dictyoxylon-rind of Brongnart. A fossil stem in the writer's possession shows, in addition to the woody cylinder, scattered vascular bundles running up through the thick pith. Under the name Heterangium, Williamson has described a fossil plant with a similar arrangement. This condition, which combines the characters of endogen and exogen, is very exceptional among existing plants; species of Aralia and Phytolacca are among the few examples known. Williamson is also of opinion that in some lepidodendroid plants secondary thickening occurred within the pith, a peculiarity unknown in living plants.

A longitudinal section of a stem under the microscope in all cases shows the woody bundles to be made up of elongated tubes and cells, the walls of which exhibit dots, rings, spirals, and various other marks. In ferns and Lycopods the cell-walls are crossed by horizontal bars giving the ladder-like or scalariform character. Wood vessels are formed by the fusion of vertical rows of cells. Some of the larger of these, from the resemblance which their ring-like marking gives them to the windpipe of an animal, are named tracheæ. Strings of cells in which the partitions still remain also occur; such cells are the tracheïdes, so-called because of their likeness to the true vessels or tracheæ. Vessels proper are most abundant in the primary bundles forming the oldest wood next the pith; the bulk of the secondary wood, in conifers almost the whole of it, consists of tracheïdes. These are elongated tubular or prismatic cells, with oblique or tapering ends which dovetail with those of the cells above and below, and are distinguished as pitted, scalariform or spiral, according to their markings. Tracheïdes are not uncommonly six-sided, giving to the wood a columnar structure resembling on a small scale the basaltic pillars of Fingal's Cave or the Giant's Causeway. The arrangement of the tracheïdes often reminds one of a collection of organ pipes. The wood of the common arbor vitæ has an exceedingly beautiful structure; the tubular tracheïdes resemble so many glass flutes with the row of pits corresponding to the stops of the instrument. Crossing the transparent flutes, as if to bind them together, at intervals are seen the rows of brick-like cells so characteristic of medullary rays. Tracheïdes and medullary rays cross each other very much as warp and woof do in cloth, to which the texture of wood has some analogy.

Coniferous wood is easily recognized; its constituent tracheïdes exhibit the characteristic markings known as bordered pits. Each pit presents the appearance of a small circle surrounded by a larger one; the shape and arrangement of the pits vary, however, in different groups of Coniferæ. Göppert recognized four, but Krauss distinguishes six distinct types of fossil wood. Taxites, represented by the modern yew, has only been obtained from Tertiary rocks; the cypress type is found in the

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chalk, and the pine and cedar type from the Trias onwards; but all the wood of the older formations exhibits the araucarian structure. In palæozoic wood of the araucaroxylon type each tracheïde commonly exhibits several rows of pits crowded together and mutually compressed, so that the outer circle or border of each pit presents a hexagonal rather than circular outline, giving a tesselated appearance to the markings as though the cell-wall were overlaid with minute mosaic. Coniferous wood is much simpler than that of dicotyledons; the latter includes, beside tracheïdes, cells and fibres of various kinds. Palæozoic is therefore distinguished from modern wood by the greater uniformity and simplicity of its structure.

The various elements entering into the composition of vegetable tissues and their symmetrical arrangements often give to microscopic sections, both of living and fossil plants, a remarkably beautiful appearance. The transverse section of the stalk of the common bracken, for example, is a lovely object presenting an elegant lace-like pattern. This feature is retained even in the fossil; silicified fern stems from Saxony have long been cut and polished wholesale on account of the graceful designs which the sections present. The starling's-breast mineral, or staarstein of the Germans, is also a fossilized fern, being formed from the stalks of species of Parsonieæ, and in the wood opals petrified vegetable tissues even attain the dignity of precious stones. We have only touched the fringe of a large and interesting subject, but if we have succeeded in conveying the impression intended, the reader will have been able to form some slight conception of the singularly charming field of investigation opened up by fossil botany.

THE FACE OF THE SKY FOR FEBRUARY.

By Herbert Sadler, F.R.A.S.

WHENEVER the Sun is visible, its disc should be watched for spots and faculæ. On moonless nights the zodiacal light should be looked for in the south-west shortly after sunset. Conveniently observable minima of Algol occur at 9h. 10m. P.M. on the 2nd; 6h. 0m. P.M. on the 5th; 10h. 53m. P.M. on the 22nd; and 7h. 42m. P.M. on the 25th.

Mercury is an evening star, and is well situated for observation during the last two thirds of the month—in fact, this will be the most favourable evening apparition in the whole year. On the 11th he sets at 5h. 58m. P.M., or 54m. after sunset, with a southern declination of 11° 43′, and an apparent diameter of $5\frac{1}{4}''$, $\frac{93}{100}$ths of the disc being illuminated. On the 16th he sets at 6h. 32m. P.M., or 1h. 18m. after the Sun, with a southern declination of 7° 42′, and an apparent diameter of $5\frac{1}{2}''$, $\frac{84}{100}$ths of the disc being illuminated. On the 20th he sets at 6h. 58m. P.M., or 1h. 34m. after the Sun, with a southern declination of 4° 25′, and an apparent diameter of $6\frac{1}{4}''$, $\frac{71}{100}$ths of the disc being illuminated. About this time he is at his greatest brilliancy. On the 26th he sets at 7h. 20m. P.M., or 1h. 48m. after the Sun, with a southern declination of 0° 6′, and an apparent diameter of $7\frac{1}{4}''$, rather less than $\frac{6}{10}$ths of the disc being illuminated. He is now at his greatest eastern elongation (18° 5′). While visible, Mercury passes through part of Aquarius into Pisces. On the evening of the 15th he will be closely *s. f.* λ Aquarii, 4th magnitude, planet and star being visible in the same field of view with a low power eye-piece; and on the 18th he will be near the 4th magnitude star φ Aquarii.

Venus is not very well situated for observation during February. On the 1st she sets at 7h. 13m. P.M., or 2h. 23m. after the Sun, with a southern declination of 4° 4′, and an apparent diameter of 55″, $\frac{8}{100}$ths of the disc being illuminated, her brightness being little more than half what it was on January 11th. On the 10th she sets at 6h. 24m. P.M., with a southern declination of 3° 43′, and an apparent diameter of 60″, $\frac{2}{100}$ths of the disc being illuminated, and her brightness being only about one-fifth of what it was on January 11th. After this she comes too near the Sun to be visible. She is in inferior conjunction with the Sun on the 16th, and after this becomes a morning star, but still too near the Sun to be conveniently observed. During the first ten days of February Venus describes a short retrograde path in Aquarius, without approaching any very bright star.

Mars and Uranus are both, for the purposes of the amateur, invisible.

The minor planet Pallas comes into opposition with the Sun on the 15th, her distance from the earth being about 115 million miles. On the 1st her R.A. is 9h. $28\frac{3}{4}$m., southern declination 20° 20′. On the 15th her R.A. is 9h. $18\frac{1}{2}$m., southern declination 15° 39′. On the 28th her R.A. is 9h. 11m., southern declination 10° 11′. She will appear as a $6\frac{1}{2}$ magnitude star during February, and may thus be possibly visible to the naked eye in the absence of moonlight. During the month she describes a retrograde path in Hydra, without approaching any naked eye star.

Jupiter is the brightest object in the evening sky, but his diameter is perceptibly decreasing. He sets on the 1st at 2h. 12m. A.M., with a northern declination of 17° 28′, and an apparent equatorial diameter of 40·8″. He sets on the 11th at 1h. 36m. A.M., with a northern declination of 17° 42′, and an apparent equatorial diameter of 39·4″. On the 28th he sets at 8h. 40m. A.M., with a northern declination of 18° 14′, and an apparent equatorial diameter of 37·4″. He pursues a short direct path in Taurus during the month, but does not approach any naked eye star. The following phenomena of the satellites occur while the planet is more than 8° above and the Sun 8° below the horizon:—On the 1st an eclipse reappearance of the first satellite at 8h. 2m. 8s. P.M. On the 2nd a transit egress of the second satellite at 6h. 34m. P.M.; a transit ingress of its shadow at 6h. 48m. P.M., and a transit egress of the shadow at 9h. 10m. P.M. On the 4th an occultation reappearance of the third satellite at 5h. 53m. P.M.; its eclipse disappearance at 9h. 23m. 9s. P.M., and its eclipse reappearance at 11h. 6m. P.M. On the 6th an occultation disappearance of the first satellite at 11h. 59m. P.M. On the 7th a transit ingress of the first satellite at 9h. 9m. P.M.; of its shadow at 10h. 29m. P.M.; a transit egress of the first satellite at 11h. 22m. P.M.; an occultation disappearance of the second satellite at 11h. 49m. P.M. On the 8th a transit egress of the shadow of the first satellite at 0h. 42m. A.M.; its occultation disappearance at 6h. 27m. P.M., and its eclipse reappearance at 9h. 58m. 2s. P.M. On the 9th a transit ingress of the second satellite at 6h. 47m. P.M.; a transit egress of the shadow of the first satellite at 7h. 11m. P.M.; a transit egress of the second satellite at 7h. 11m. P.M.; a transit ingress of its shadow at 9h. 26m. P.M., and its transit egress at 11h. 48m. P.M. On the 11th an eclipse reappearance of the second satellite at 6h. 5m. 9s. P.M.; an occultation disappearance of the third satellite at 7h. 51m. P.M., and its occultation reappearance at 9h. 54m. P.M. On the 14th a transit ingress of the first satellite at 11h. 4m. P.M. On the 15th an occultation disappearance of the first satellite at 8h. 23m. P.M., and its eclipse

reappearance at 11h. 53m. 55s. P.M. On the 16th a transit ingress of the shadow of the first satellite at 6h. 53m. P.M.; a transit egress of the satellite at 7h. 47m. P.M.; a transit egress of its shadow at 9h. 6m. P.M.; a transit egress of the second satellite at 11h. 50m. P.M., and a transit ingress of its shadow five minutes after midnight. On the 17th an eclipse reappearance of the first satellite at 6h. 22m. 57s. P.M. On the 18th an occultation reappearance of the second satellite at 6h. 8m. P.M.; its eclipse disappearance at 6h. 25m. 19s. P.M.; its eclipse reappearance at 8h. 41m. 27s. P.M.; an occultation disappearance of the third satellite at 11h. 54m. P.M. On the 22nd a transit ingress of the shadow of the third satellite at 7h. 27m. P.M.; its transit egress at 9h. 25m. P.M.; an occultation disappearance of the first satellite at 10h. 20m. P.M. On the 23rd a transit ingress of the first satellite at 7h. 30m. P.M.; a transit ingress of its shadow at 8h. 49m. P.M.; a transit egress of the satellite at 9h. 43m. P.M., and a transit egress of its shadow at 11h. 2m. P.M. On the 24th an eclipse reappearance of the first satellite at 8h. 18m. 47s. P.M. On the 25th an occultation disappearance of the second satellite at 6h. 22m. P.M.; its occultation reappearance at 8h. 47m. P.M.; its eclipse disappearance at 9h. 1m. 28s. P.M., and its eclipse reappearance at 11h. 17m. 52s. P.M. On the 27th a transit egress of the shadow of the second satellite at 6h. 25m. P.M.

Saturn is an evening star, rising on the 1st at 11h. 22m. P.M., with a southern declination of 7° 21′, and an apparent equatorial diameter of $17\frac{3}{4}''$ (the major axis of the ring being 40·7″ in diameter, and the minor 10·0″). On the 28th he rises at 9h. 31m. P.M., with a southern declination of 7° 1′, and an apparent equatorial diameter of $18\frac{1}{4}''$ (the major axis of the ring system being 42·5″ in diameter, and the minor 10·1″). He is almost stationary in a barren region of Virgo during February.

Neptune is an evening star, setting on the 1st at 3h. 51m. A.M., with a northern declination of 20° 34′, and an apparent diameter of 2·6″. On the 28th he sets at 1h. 57m. A.M., with a northern declination of 20° 35′. He is almost stationary in Taurus during the month. A map of the small stars near his path will be found in the *English Mechanic* for November 29th, 1893.

There are no very well-marked showers of shooting stars in February.

The Moon is new at 9h. 45m. P.M. on the 3rd; enters her first quarter at 10h. 43m. A.M. on the 13th; is full at 2h. 16m. A.M. on the 20th; and enters her last quarter at 0h. 28m. P.M. on the 27th. She is in apogee at 10h. P.M. on the 1st (distance from the earth 252,320 miles); and in perigee at 9h. P.M. on the 17th (distance from the earth 225,610 miles).

Chess Column.

By C. D. LOCOCK, B.A.Oxon.

COMMUNICATIONS for this column should be addressed to C. D. LOCOCK, Burwash, Sussex, and posted on or before the 12th of each month.

Solutions of Problem No. 6.

Author's Key-move—1. Q to Bsq.
Solved also by 1. Kt to B4ch.

Solutions of Problem No. 7.

Author's Key-move—1. Q to Kt8.
Solved also by 1. Q to B6ch, and 1. K to B8.

Here the "*Coquus*," sportively alluded to by the composer, is present with his attendant handmaid.

According to the published rules, duals do not score in either of the above problems.

Solution of Problem No. 8.

Key-move—1. Q to R6.

If 1. . . . K × R,	2. Q to Q2ch.
1. . . . B moves,	2. R to K3ch.
1. . . . Kt × R or KtB7,	2. B × Pch.
1. . . . Kt elsewhere,	2. Q or R mates.

In this problem there is a dual short mate after three of Black's possible moves. If this dual had scored at all it would have scored as one dual and not as three. But it does not score for the following reasons. The published rule reads—"Marks will be awarded as follows: For each dual continuation (on the second move), one point." Now a "continuation" is something *between* the key and the mate; a move made after the key, with a view to a mate. A mate is the *end*, and cannot therefore be a "continuation." If it is urged that the rule quoted contains the words "dual continuation (on the second move)," the reply is that the words "on the second move," being in parentheses, are merely explanatory of the word "continuation," which, in a three-move problem, invariably occurs on the second move. The reason why dual short mates, and dual third-move mates, do not score is that every solver is presumed to be capable of seeing every possible mate in one move.

We may mention that a well-known expert, to whom we submitted the case in point, entirely concurs in our view of the matter.

CORRECT SOLUTIONS received from the following:—

Eighteen Points.—Semper, B. G. Laws, Guy.

Fifteen Points.—Kt. J., F. R. Adcock, W. T. Hurley, A. C. Challenger.

Twelve Points.—W. J. Jubb, Rascal, Buttercup, A. R., Chat.

Nine Points.—Alpha, Birkenbaum, H. Holmes, J. H. Christie, E. W. Brook.

Nos. 6 and 7, correctly solved by L. Bourne and A Norseman.

T. E. Ewing.—The Knight must be lost. If for instance 23. . . . P to QR4, 24. Q to QB2, threatening mate. Or if 23. . . . B to R8, 24. P to B3, threatening the same continuation if Black defends the Bishop.

G. D. Crowther.—If 1. Kt. to K7ch, K moves; 2. Q to B2, R × Kt, and there is no mate.

H. S. Brandreth.—In No. 7, 1. Kt to B6 is nullified by 1. . . . B to Q5.

L. Bourne.—In No. 8, 1. B × Pch comes very near. But have you looked at the reply 1. . . . Kt × B?

W. T. Hurley.—White must not postpone the mate even to obtain variety.

LEADING SOLVERS' SCORES.

Semper	36	Chat	29
B. G. Laws	36	Rascal	29
Guy	36	Buttercup	29
Kt. J.	33	W. J. Jubb	27
F. R. Adcock	33	Birkenbaum	25
A. C. Challenger ...	33	H. Holmes	25
W. T. Hurley ...	32	J. H. Christie ...	24
A. R.	29	A Norseman	22

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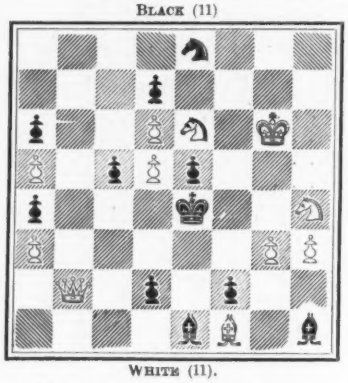
POSITION No. 9.

"*Lieblich sind überstandene Mühen.*"

BLACK (11)



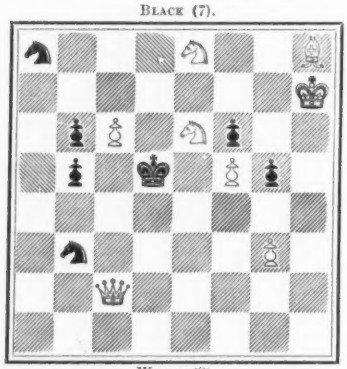
WHITE (11).

White mates in three moves.

POSITION No. 10.

"*Nulli Secundus.*"

BLACK (7).



WHITE (8).

White mates in three moves.

CHESS INTELLIGENCE.

A second tournament, closely following on that which resulted in Mr. Lasker's bloodless victory, was recently held at the Manhattan Club, New York. The players this time were all Americans with the exception of Herr Albin, who came out fourth. Mr. H. N. Pillsbury, of Boston, whose creditable performance in the previous tournament was anticipated in this column, took the first prize, Mr. A. B. Hodges being second, and Mr. J. W. Showalter third. Mr. E. Delmar occupied an unaccustomed position at the bottom of the list of ten competitors.

The contests among the southern counties are exciting unusual interest this year. Sussex have defeated a weak Hampshire team, but lost to Surrey, who have also gained a decisive victory over Kent. The use of clocks is now enforced.

A very successful three days' "Chess Festival" was recently held at Hastings. Messrs. Bird, Blackburne, and Gunsberg all gave simultaneous performances, Mr. Bird coming out with slightly the best score. Three consultation games were also played, each of the three masters mentioned being partnered by members of the Hastings club. In these games Mr. Gunsberg had, perhaps, the best score, Mr. Bird being hardly in his best form.

Examples of Chess Master-play (Second Series), by C. T. Blanshard, M.A., is a well-arranged collection of seventy-six annotated games played by the masters and leading amateurs of all countries. English amateurs are well represented. Each game has a diagram, while the notes are taken from various sources. Short biographical notices of the players are appended, ranging in length from two or three words to eight lines in the case of a certain "eminent English theorist." The book is published at 2s. by Messrs. Simpkin, Marshall & Co.

Principles of Chess, by James Mason (Horace Cox, *Field* Office). Mr. Mason rivals Mr. Blackburne as a scientific exponent of the game of chess; as a scientific expounder of the game he has probably no equal in this country. The present handsomely bound volume of nearly 300 pages is published at the extremely low price of 2s. 6d. It is intended mainly for the learner, but there are few who cannot learn much from it.

Beginning with a description of the powers of the various pieces and the principles of playing them, the author proceeds to give numerous diagrams illustrating the way to take advantage of early mistakes. This is followed by a chapter on mates, and a comprehensive survey of the leading end-game positions. After a preliminary discussion on "attack" and "defence," fifty diagrammed middle-game combinations are shown; and here the author must be thanked for his thoughtfulness in placing the winning side, whether White or Black, next the reader. These combinations are all from modern match-play, and, though the names of the players are purposely withheld, many will recognize some of the positions. The openings, according to Mr. Mason's logical method, come last in order and perhaps least in importance. His plan is to illustrate the principal openings by means of annotated games, whole openings being sometimes most clearly and concisely explained in the notes to these games. We are glad to see that the author has included his own immortal Giuoco Piano with Winawer (1882).

The whole work is most original and suggestive, and if Mr. Mason may be considered by some to err in the direction of too much science, readers of KNOWLEDGE should be the last to find fault with him for this. Problems are the only department of the game (to beg the question) not represented in the book. But Mr. Mason does not consider that problems are Chess. We almost omitted to mention the excellent portrait of the author which adorns the volume.

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